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Large Guyed Derricks for Erecting Structural Steel Work.

For the erection of the steel framework of the Insurance Exchange Building, Chicago, the contractors are using guyed derricks of unusual size and operated by electric hoists. The building is 202 ft. square and will be 295 ft. high from the sidewalk to the roof of the pent house; it has three street fronts, on Jackson Boulevard, Fifth Ave. and Sherman St. The entire area is served by four derricks, and these can set the steel work for two stories before being raised.

The masts and booms are of round timber, turned to shape like ship's spars, with a maximum diameter of 23 ins. and 18 ins. respectively. The height of mast is 95 ft. and the length of boom 83 ft. The working radius or reach ranges from a minimum of 3 ft. to a maximum of 75 ft. Each derrick has a hoisting capacity of 15 tons, and is served by a 50-HP. electric hoist built by the Thomas Elevator Co. The use of these electric hoists avoids noise and dirt incident to steam hoisting engines, and also avoids the trouble of delivering fuel; at the same time fewer men are required to operate the plant. This erection plant was devised by the Thompson-Starrett Co., of Chicago, which has the contract for the building, and we are indebted to the company for information concerning it. The architects are D. H. Burnham & Co. The accompanying view shows three of the derricks erected; the fourth corner of the site not being cleared. Two steam shovels are at work excavating this part of the site to the basement level, from which wells will be sunk for the concrete foundation piers. At the rear of the site is the concrete mixing plant.

ERECTING A STEEL BUILDING WITH 95-FT. GUYED DERRICKS AND ELECTRIC HOISTS: INSURANCE EXCHANGE, CHICAGO.
(Thompson-Starrett Co., Chicago, Contractors)

Intercepting Sewers and Stream Improvements at Syracuse, N. Y.

By STEPHEN B. VERNON,* Assoc. M. Am. Soc. C. E.

The discharge from the combined city sewer system into the two small streams flowing through the city of Syracuse has created conditions which have been for many years the subject of criticism and complaint. For the permanent removal of these conditions, there is now in course of construction a system of intercepting sewers, and in addition each stream is being deepened and lined with concrete for the greater part of its course through the city. In general, the interceptors follow the plans made in 1895 by Mr. Samuel M. Gray, M. Am. Soc. C. E., Consulting Engineer. These plans were held in abeyance for several years, for it was not until 1907 that, by an Act of the State Legislature, the Syracuse Intercepting Sewer Board was created. Under the surveillance of this Board, and the immediate direction of Mr. Glenn D. Holmes, M. Am. Soc. C. E., Chief Engineer, Mr. Gray's plans, however, have been largely modified to meet present conditions, and the construction of the contemplated improvements is now well advanced.

Syracuse (Fig. 1) is situated at the head of Onondaga Lake, a body of water with an area of about 4½ square miles, draining north through the Seneca and Oswego rivers to Lake Ontario. Northerly, in a course approximately parallel to and not far from the axis of the business district of the city flows Onondaga Creek, whose drainage area includes about 113 square miles, and to this stream 80% of the total city area is tributary. Its mean monthly discharges may be said to lie between 40 and 425 cu. ft. per sec., equivalent, respectively, to run-offs of .35 and 3.75 sec.-ft. per sq. mi.; no reliable record exists of a daily discharge greater than 3,750 sec.-ft. Through the extreme western part of the city, and toward the north, flows Harbor Brook. The discharge of this stream has been ascertained only at infrequent intervals, but it seldom exceeds 30 cu. ft. per sec., or 3 sec.-ft. per sq. mi. of drainage area. These two streams enter Onondaga Lake within the city boundaries. Neither has been used to any considerable extent as a source of the city's water-supply, which is, and has been these twenty years, obtained from Skaneateles Lake, distant some 19 miles to the southwest. Nor are the streams through which Onondaga Lake contributes its waters to Lake Ontario used as a source of other potable water-supply.

In 1895, when Mr. Gray's plans were made, the city population numbered about 95,000; the Federal Census of 1910 placed it at 137,500. Inevitable results have followed the discharge of the sewage from so large a population into streams of so small a flow. During the summer months, foul organic matter accumulated along the banks of both streams causes a well-nigh unbearable stench, and the resulting discomfort to the occupants of neighboring buildings will be readily conceived.

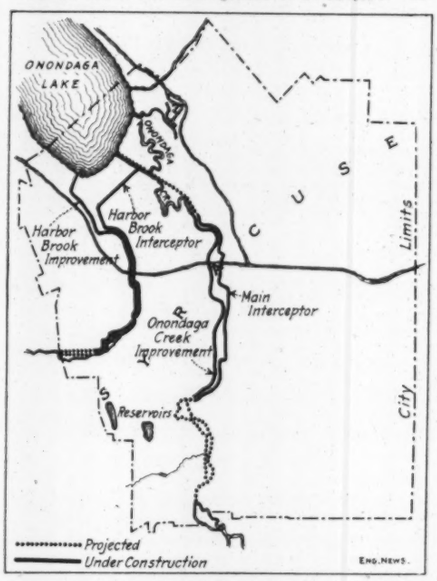

Fig. 1. General Map of Syracuse, N. Y., Showing Location of Intercepting Sewers and Stream Improvements.

Intercepting Sewers.

Under the present designs, there are in process of construction two intercepting sewers (Fig. 1); the larger, following the course of and purposed to preclude sewage from Onondaga Creek, will be herein referred to as the main interceptor, and the smaller, with a corresponding relation to Harbor Brook, will be termed the Harbor Brook interceptor. The whole system, complete, comprises but these two interceptors with their several branches, a junction being provided at the northern end of the city near the lake, from which point it is proposed to conduct the sewage to a disposal plant. The present per capita water consumption in Syracuse is about 90 gals. per day. The intercepting sewers are designed to accommodate a discharge of 375 gals. per capita per day from a population of about 410,000. This allows for what is termed double sewage: equal volumes of sewage and of storm water; the assumption being that the maximum actual sewage discharge will not exceed 125 gals. per capita per diem, and further, that an excess allowance of 50% will provide for the maximum rate of discharge at any time. The assumed population of 410,000 is based upon densities of from 30 to 85 persons per acre of area for various sections of the city, the average density for the whole area being about 37.5 persons per acre. From the street sewers "double sewage" is the maximum amount which may be intercepted, and excess storm water will be discharged directly to the streams through the present outlets. At such times, however, the dilution will be such as to prevent nuisance.

METHODS OF INTERCEPTION.—The interception of sewage from the street or lateral sewers is accomplished by means somewhat variant for the two interceptors. In all cases, a manhole, termed an intercepting chamber, is constructed over the lateral sewer at a point suitable for interception, so as to provide easy access for purposes of cleaning, repairing, or adjusting. Through one side of each lateral sewer served by the main interceptor, an opening is made, and this opening connects with a pipe line leading to the interceptor; just below these openings small concrete dams, whose crests are fixed at about the elevation of flow of double sewage, serve to divert the required discharge. From each sewer served by the Harbor Brook interceptor, sewage is removed through the sewer invert by means of a leaping-weir device (see Fig. 2), this being essentially an opening partially covered with an adjustable gate. Up to certain stages of flow in the laterals, all sewage drops through the openings and passes thence through pipes connecting with the interceptor; during greater discharges, however, the excess sewage leaps the openings and passes thence to the brook. A series of experiments, undertaken in connection with the study of the leaping-weirs, served to indicate that with a weir of proper design, for any stage of flow higher than that at which sewage begins to leap the opening, a constant quantity may be intercepted.

Where the pipe lines conveying sewage from the intercepting chambers join the interceptors, manholes, termed valve chambers, are constructed. Each pipe line terminates in a valve (see Fig. 3) whose pivoted gate is actuated by the vertical movement of a copper float. On the main interceptor (Fig. 3) each valve with its float is confined in a stilling compartment at one side of the sewer, but on the Harbor Brook interceptor (Fig. 4) separate stilling compartments on opposite sides of the sewer are provided for the valves and for the floats. The movements of the valve gates and of the floats are reciprocal; as the floats rise with an increased depth of sewage flow, the valve gates fall and shut off inflow from the lateral sewers, and vice versa. The floats, moreover, may be so

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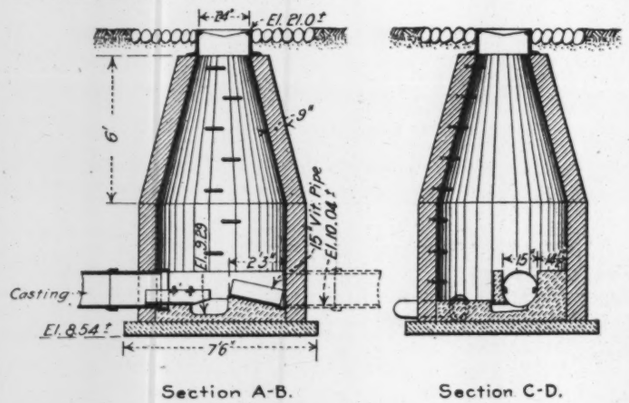
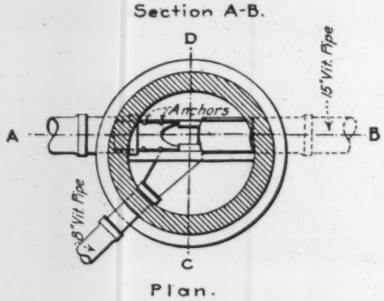
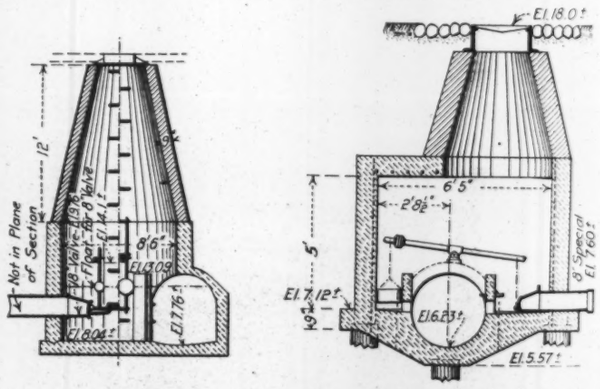


Section A-B. Section C-D.



Plan.

FIG. 2. INTERCEPTING CHAMBER WITH LEAPING WEIR, HARBOR BROOK SEWER.



Main Sewer. Harbor Brook Sewer.

FIG. 3. VALVE CHAMBERS FOR INTERCEPTING SEWERS, SYRACUSE, N. Y.

adjusted as to establish the maximum discharge in the interceptors at any desired depth above a certain minimum.

SIPHON CONNECTIONS.—The relative elevations of the main interceptor and of the adopted grade line for the improved Onondaga Creek channel are such that at various points it is found necessary to conduct sewage intercepted from the laterals across the creek to the main interceptor through inverted siphons. There will be constructed in all eleven of these siphon crossings. Each crossing terminates in a manhole on either side of the creek; that on the one side being connected with an intercepting chamber, and that on the other side with a valve chamber. The siphons proper (see Fig. 4) are made up of duplicate cast-iron pipes surrounded with concrete. These are laid in right lines between the terminal manholes, and within the manholes they turn normally through flanged tees and rise to such heights as are required. In diameter, the pipes vary from 6 to 14 ins., and in length between manholes, from 82 to 156 ft. To the horizontal openings of the flanged tees are bolted wrought-iron plates and in the vertical portions of the pipes above are cut-off valves and hose connection plugs for water from the city mains. For purposes of cleaning, standard sewer-cleaning rods coupled in 4-ft. sections may be easily run through from manhole to manhole, or connection may be made with the city water mains under a pressure of about 100 lbs. per sq. in. The capacity of the pipes and their arrangement is such that for dry-weather flow but one pipe is in service, both being required, however, for the discharge of double sewage. The maximum velocities in the crossings are from 3 to 4½ ft. per sec. In connection with the Harbor Brook interceptor but one siphon crossing was required, free discharge to the interceptor being elsewhere arranged under the brook.

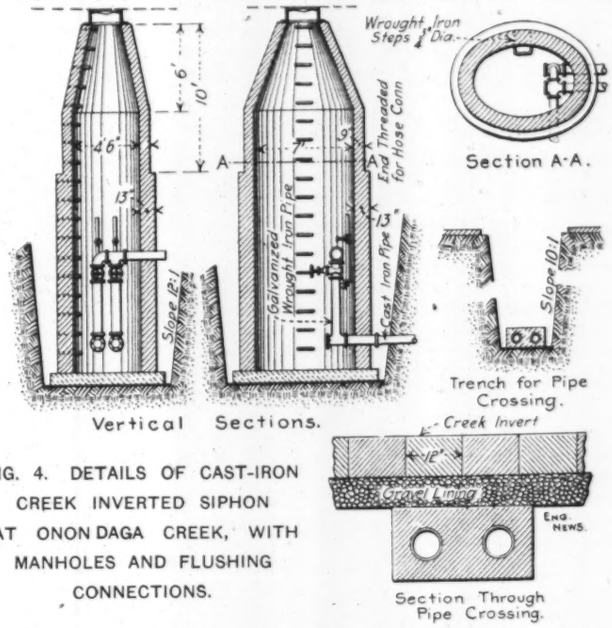


FIG. 4. DETAILS OF CAST-IRON CREEK INVERTED SIPHON AT ONONDAGA CREEK, WITH MANHOLES AND FLUSHING CONNECTIONS.

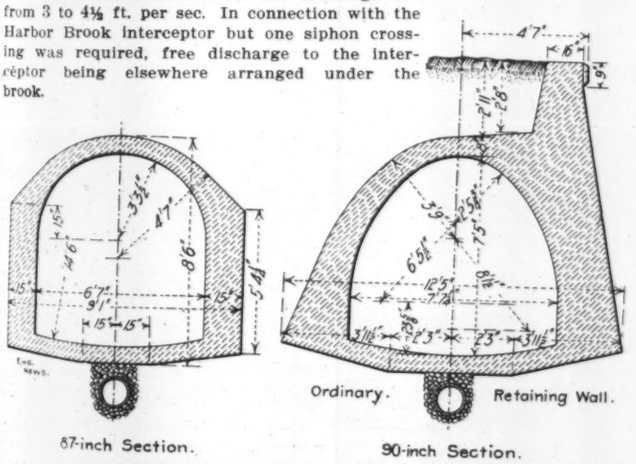


FIG. 5. SECTIONS OF MAIN INTERCEPTING SEWERS.

SEWER SECTIONS.—Concrete was adopted as the material of construction for both interceptors, and though a brick invert lining was at one time considered, the protection afforded, of somewhat doubtful value, was not deemed proportional to the increased cost. In the determination of the sewer sizes Kutter's formula was used, n being assumed at .013. The elevations of the interceptors, at their junction in the northern end of the city, are limited by the water level of Onondaga Lake and at various other points along their routes by the elevations of existing lateral sewers to be served. The adopted grades are the maximum attainable under existing conditions and give velocities for full discharge of from 3 to 5 ft. per sec. For the main interceptor two types (Fig. 5) are used, the wide-base section through the lowlands near Onondaga Lake, and the vertical-wall section elsewhere (the given dimensions being those for the largest size of each type). The depth of fill over the former is but 2 ft., and over the latter from 10 to 30 ft. The retaining wall modification of the wide-base section supports a roadway running along the creek bank. The vertical diameter of that portion of the main interceptor now under construction varies from 33 ins. at the upper end to 90 ins. at its point of discharge to the creek. The contract drawings show three alternative forms of construction, plain concrete, reinforced-concrete and reinforced-concrete pipe, the latter limited to sections whose vertical diameter does not exceed 56 ins. The contractor's prices were lowest, however, for the plain concrete construction and this was therefore adopted. For the Harbor Brook interceptor, two alternatives were offered for the sections between 33 and 56 ins. in diameter; the one, reinforced-concrete construction and the other, reinforced-concrete pipe; the latter is being used in the work. A pile foundation is required for the greater part of this sewer, and the method of supporting the concrete pipe on a single row of piles is shown in Fig. 6. The smaller sizes of this interceptor have plain concrete side walls and invert, and a top of reinforced-concrete slabs separately molded and grouted in place.

Both interceptors cross under the Erie Canal, which extends east and west through the center of the city. The portions of the sewers under the canal were constructed in open cut during the closed season of the canal navigation. In each case the excavated stone masonry canal walls were rebuilt of concrete masonry and concrete cut-off walls were constructed at a distance of about 10 ft. from the face of the canal walls.

Just north of the Erie Canal, along the Harbor Brook interceptor, there is a sharp declivity in the ground surface. A corresponding break in the sewer grade is made in a drop manhole, the velocity of discharge therein being broken by two large, staggered stone slabs built across opposite sides of the manhole. Here, both a sewer intake from, and an outlet to, the brook is arranged so that the brook discharge may be diverted to the sewer for flushing purposes, or the sewer discharge may be diverted to the brook. A similar intake was arranged for this sewer at its southern terminus.

CONSTRUCTION.—Contracts for the Harbor Brook interceptor have been but recently awarded and only a small portion of the work is completed. These contracts include also the brook improvement construction; one covers the work north of the Erie Canal, and another the portion south of the canal. The former is being executed by the John Young Contracting Co. and the latter by Charles T. Hookway, both of Syracuse. The present contracts include about 2½ miles of intercepting sewer, ranging in vertical diameter from 25 to 54 ins., and cover all but a very small portion of the contemplated Harbor Brook system.

The contract for the main interceptor was awarded in June, 1909, and is now being executed by William Fitzgerald, of Skaneateles, N. Y. This contract, however, covers only a little more than half of the whole length of the contemplated main intercepting sewer system. The section through the extreme southern portion of the city will be constructed at a later date, and the construction of that portion through the extreme northern part of the city has been deferred pending the decision of the State Engineering Department as to the location of a barge canal harbor in this vicinity. The contract now under execution includes some 2½ miles of intercepting sewer, ranging in vertical diameter from 33 to 90 ins. This portion of the interceptor provides for almost the entire present developed business and residential sections of the city, the sewage from which now reaches Onondaga Creek. A temporary outlet to the creek is provided in the northern part of the city, well beyond the point where the presence of sewage may prove a nuisance to the owners of neighboring property.

The original plans for the main interceptor contemplated open-trench construction throughout except under railway crossings, where construction in tunnel is required. It has also been found advisable to construct certain portions in tunnel through those city streets where traffic is the most congested. For this tunnel construction, bents of 8 × 8-in. uprights resting on 3 × 8-in. sills, with 8 × 10-in. caps, were spaced about 4 ft. c. to c., and the roof was driven with 3-in. planking. At sewer depth, the greater part of the soil along the line is coarse, running gravel and the ground-water table lies normally at about half depth of the sewer itself. Single or double lines of 10 or 12-in. vitrified pipe underdrain have been used to conduct the ground water to pump wells, spaced from 200 to

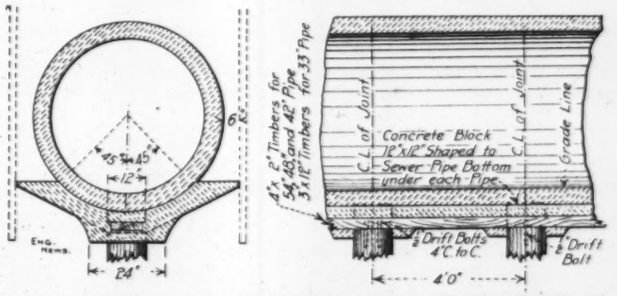


FIG. 6. METHOD OF SUPPORTING HARBOR BROOK SEWER ON PILES.

1,000 ft. apart and drained by means of centrifugal pumps discharging generally into the larger lateral street sewers leading to the creek.

The depth of cut for open sewer trenches in business portions of the city ranges from 25 to 35 ft. These excavations have been carried on with Potter and Moore trenching machines of the bucket-conveyor type. The excavation of that portion of the trench through the lowlands near the lake, where the depth of cut seldom ex-

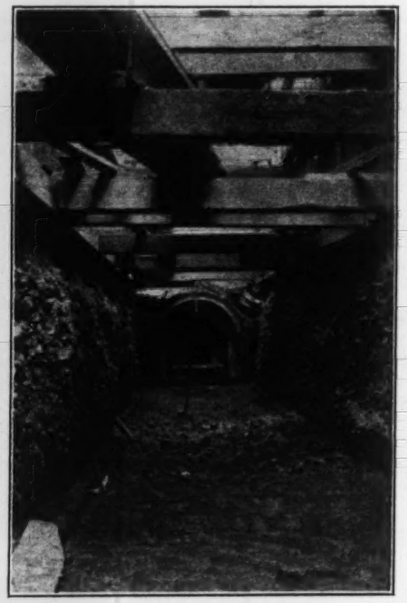


Fig. 7. View of Sewer in Deep Trench.

ceeds 10 ft., was done by hand. All but the very bottom of the deep trench is sheeted and braced with timber (see view, Fig. 7). At sewer depth steel sheeting is driven and used as the outside form for the concrete masonry, being well oiled or otherwise prepared to facilitate withdrawal after the sufficient setting of the concrete.

In the construction of the concrete sewer, the invert is first laid and shaped by means of templates set to grade, and on either side dovetailed key ways are made for the joining of the side walls thereto. Collapsible steel forms are then set up, the invert construction being kept well in advance, and the whole sewer arch is completed in one operation. In open trench from 20 to 50 ft. of steel forms are set up at one time, but in tunnel the sewer is constructed in 8-ft. lengths, and each section is allowed to harden and the backfilling is performed before another is undertaken. In all, some 2,400 ft. of sewer will be constructed in tunnel; about one-half the entire length of sewer, including the most difficult portions, has already been completed. The concrete for sewer construction is mixed in the proportions of 1 part cement to 7½ parts fine and coarse aggregates, the relative quantities of the latter being determined by tests for maximum density; the usual proportions are 1:3½:4. Sand is used for the fine aggregate and both crushed stone and gravel have been used for the coarse.

SURVEYS AND PREPARATION OF PLANS.—The surveys for the sewer contracts included the location of all buildings and all surface and underground structures of every description along the proposed sewer route, and the running of profiles along the center line. Wash-drill borings were made at intervals of about 300 ft. and samples of the various materials encountered were obtained and stored for future reference. At each of the borings the ground-water level was ascertained and its daily fluctuation at certain points has been recorded for periods ranging from one to several months. All of this information is shown, so far as practicable, on the contract drawings, and the final sheet in each set displays a tabulated summary of the materials required for various parts of the work.

For the computation of sewer discharges, sets of convenient diagrams were prepared. One set, on a logarithmic basis, shows the discharges and velocities of circular sections computed by Kutter's formula with various values of *n*. Another shows the hydraulic elements for each type of sewer section adopted, and on these are noted the areas, discharges, etc., in terms of those of a circular section (Fig. 8). Thus, for any depth of flow, the discharge, velocity, discharge area or perimeter for each of the adopted sewer sections may be determined with but two or three references to the diagrams. Their use has resulted in the saving of much time and labor.

Onondaga Creek Improvement.

Attempts to improve Onondaga Creek by excavating the channel to a regular section have been made in the past, the last about the year 1905. These have resulted only in the demonstration of the necessity for a permanent channel protection to prevent erosion and the formation of bars. Sand and gravel form the creek bed proper and over this lies a deposit of muck and organic matter. The general profile is very irregular. The outlets of many of the lateral sewers discharging into the creek lie below the normal water surface; their proper discharge is precluded and in many instances back water from the creek reaches the point of their intersection with the line of the main interceptor. A 60-ft. right-of-way is supposedly devoted to the creek, but many encroachments exist. Through the business district of the city factories and other buildings have been constructed along the banks even to the water line, and the clear span of some of the street bridges is less than 60 ft. The cost of widening the channel is prohibitive and the only reasonable recourse is to deepen and permanently protect it.

The area of the creek drainage basin and the amount of run-off have been already noted. The plans now under execution provide for a concrete channel lining with such grades as to allow a discharge of about 6 sec.-ft. per sq. mi. of drainage area, with a water surface at such height that all lateral sewers will have free discharge to the creek. Discharges in excess of this amount may be classed as abnormal and of so rare occurrence as to interfere but little with the operation of the main interceptor. Nevertheless, the interceptor valves will at such times, as before noted, prevent surcharge of the sewer.

The investigation of the problem resulted in the choice of a channel protection in the form of concrete blocks laid ordinarily without mortar or other bonding substance. Over monolithic concrete, the only other seriously considered form of protection, the blocks offer the advantages of a minimum of drainage requirements during construction and freedom from unbalanced water pressures; the first a feature of prime importance under the conditions encountered. Details are shown by Fig. 9, and a view of the lined channel in flood by Fig. 10. Three invert widths are used, 18, 21 and 24 ft., of which the first and last are shown in Fig. 9. The side walls have a slope of 45° and vertical heights ranging from 2 to 7 ft. for average sections. Around sharp bends the slope walls are elevated as required for ample bank protection under all conditions. To facilitate laying, all blocks are made with four identical faces. Those in the invert measure 8 × 8 × 12 ins., and those in the slope walls 6 × 12 × 12 ins. Each block has a weight of approximately 60 lbs. and may be handled by one man without difficulty. Adjacent rows of invert blocks break joints so that a toothed face is left on either side next to the slope walls, and a monolithic concrete footing is here constructed, forming at once a base for the slope-wall blocks and a bond for those in the invert. Along the top of the slope walls, also, is constructed a monolithic coping of substantial form. Where the excavated creek bed offers no satisfactory foundation for the superincumbent blocks forming either invert or slope wall, a filling of gravel is laid. The depth of excavation for the invert ranges from 4 to 8 ft. In computing the capacities of sections Kutter's formula was used,

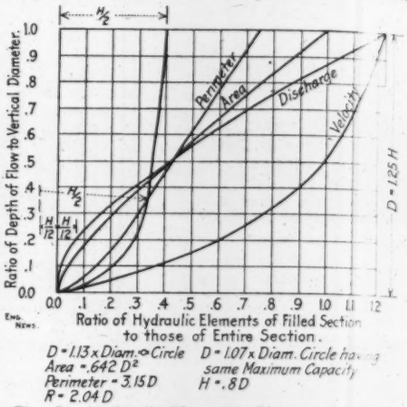

Ratio of Depth of Flow to Vertical Diameter.
Perimeter
Area
Discharge
Velocity
D = 1.25 H
Ratio of Hydraulic Elements of Filled Section to those of Entire Section.
D = 1.13 x Diam. of Circle
Area = .642 D²
Perimeter = 3.15 D
R = 2.04 D
D = 1.07 x Diam. Circle having same Maximum Capacity
H = .8 D

Fig. 8. Hydraulic-Elements Diagram for Egg-Shaped Sewers with Slab Top.

(Based on computation by Kutter's formula for section having D = 30 ins.; S = .001; n = .013.).

n being assumed at .015. The velocities for a discharge of 6 sec.-ft. per sq. mi. lie between 6 and 7 ft. per sec.

Under certain of the existing culverts and bridges over the creek, where the arrangement of piers or abutments interferes, it is impossible to adhere to the usual style of the channel protection. Here monolithic concrete curved inverts are constructed, and piers and abutments are substantially underpinned.

The work now under contract covers all but a portion of the creek in the southern part of the city, a section at present not generally developed. Here street sewers entering the creek are but few and small. It is expected to improve this part of the channel at a later date. The contract now under way includes about 2½ miles of creek improvement, all but some 1,200 ft. of which, at the northern end, will be deepened and lined with concrete. About 580,000 blocks are required for this contract.

CONSTRUCTION.—The manufacture of concrete blocks has proven a most important step in the stream-improvement construction. This has been carried on chiefly at the village of Solvay, distant some three miles from the site of the work. The Solvay Process Co., there established, use, for the manufacture of caustic soda and other related products, large quantities of crushed limestone, which is conveyed to their plant from the quarries by means of an overhead bucket cableway. The plant for block manufacture is conveniently situated so that the storage bins for crushed stone lie directly under the cableway and adjacent to other bins for the storing of sand and cement. These bins feed to a Trump continuous measuring and mixing machine. In this machine the measuring is accomplished through the use of stationary blades which sweep, from the outer portions of

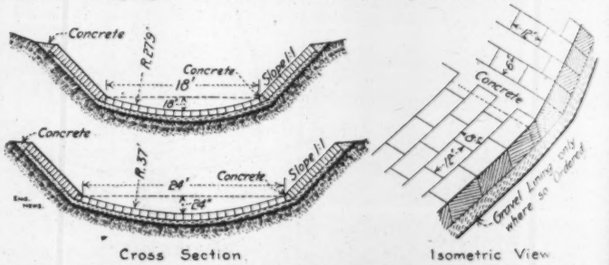


FIG. 9. DETAILS OF LINING OF ONONDAGA CREEK, SYRACUSE, N. Y., WITH CONCRETE BLOCKS.

three revolving horizontal disks, attached to a central shaft, the required proportions of the cement, sand and stone. The materials then drop into a compartment containing mixing apparatus of the puddle type. The molds for the blocks have the form of long wooden troughs, each divided into eleven compartments by means of transverse sheet-iron partitions. The blocks remain in the molds for 24 hours and are then removed and stored under cover for from one week to ten days during which time they are kept constantly moist by sprinkling. They are

FIG. 10. VIEW OF IMPROVED OR DEEPENED AND LINED SECTION OF ONONDAGA CREEK DURING HIGH WATER, SPRING OF 1911.

further seasoned for at least one week before they are placed in the work. A wet concrete mixture is used for the blocks and the proportions of ingredients are 1 part cement to 8 parts fine and coarse aggregates, the relative quantities of the latter being determined by tests for maximum density. Crushed limestone has been used for coarse aggregate and crusher dust was at first used for fine aggregate. The substitution of coarse sand for the latter was found to give better results, however.

For carrying the creek discharge over sections of the work under construction, semi-circular flumes about 10 ft. in diameter have been used. One section of flume was composed of longitudinal hard-pine strips. Along the top, wooden cross beams were spaced 3 ft. c. to c. Steel rods, closely drawn around the periphery and bolted through the ends of the beams, held the whole firmly together. The section now in use is formed of semi-circular sheet-steel plates supported by angle-irons. The flumes lie along one bank of the creek and rest on timber cross-ties. They are so constructed as to support an industrial track along which small cars carry the materials of construction to the necessary points. Dams of Lackawanna steel sheet-piling divert the flow of the creek to the flumes and centrifugal pumps are used to remove ground water from the creek bed. Excavation is made by steam shovel and material is removed to the spoil banks by means of industrial cars running along a track on the creek bank opposite that where lies the flume.

The deepening and lining of the creek through the culvert under the Erie Canal was accomplished in the winter of 1909-10. This work involved the deepening of the creek bed about 8 ft. through the central arch of a triple-arch stone culvert, and the underpinning of the adjacent walls and the laying of a concrete invert 18 ins. thick. The invert was reinforced with 1-in. diameter rods spaced 12 ins. This culvert has been standing more than 90 years and is supported on piles over which lies a timber flooring. Before the deepening of the channel was undertaken, alternate sections of side walls about 12 ft. in length were underpinned. The flooring was then entirely removed and the piles were cut off as excavation proceeded. During construction the creek discharge was diverted to one of the adjacent arches by a temporary dam and a line of 12-in. underdrain along the center of the culvert carried the ground water to the pump wells. There was considerable seepage under the side walls during excavation for the underpinning and in some instances it was necessary to lay strips of tarred paper along the sides of the prepared subgrade for the protection of the concrete laid thereon.

The creek improvement contract is being executed by William Fitzgerald, of Skaneateles, N. Y.

Harbor Brook Improvement.

This work is very similar to the improvement of Onondaga Creek, though on a much smaller scale. The bed of the brook is composed of a thick layer of muck usually overlying sand on gravel, and excavation to a depth of from 1 to 3 ft. is required. The standard protection devised for the channel (see Fig. 11) consists of a flat bottom of reinforced-concrete slabs, laid on timber stringers, and side walls of 8 × 8 × 12-in. concrete blocks, laid with a slope of 45° and capped with a monolithic concrete coping. Each slab is 12 ins. wide and 4 ins. thick, and is reinforced with two ⅜-in. square bars. At either end there is a beveled projection which affords support to the slope walls, the width between projections varying from 4 to 8 ft. The longitudinal foundation stringers are laid in two parallel rows, the ends of adjoining stringers being spiked firmly together; they serve to furnish support for the slabs and to hold them in alinement. Wherever the underlying soil is not sufficiently firm, the stringers are embedded in a gravel filling and a similar filling is laid for the support of the slope walls as conditions require.

The present street culverts over the brook are concrete or stone structures, most of them paved with either stone blocks or timber planks. These will not be disturbed, but where the culverts have no paving the brook bed will be deepened and lined with concrete blocks. Several new street culverts are included in the present contracts, of a reinforced-concrete box type. A feature of the work is the straightening of the course of the brook through the extreme southern portion of the city; a district but sparsely inhabited. The adopted alinement places the brook along city lot lines, so far as practicable, in such way as to work the least disturbance to, and indeed often to greatly benefit, adjoining property. As has been previously mentioned, the contracts for the brook improvement were combined with those for the intercepting sewer; they include about two miles of channel excavation and protection.

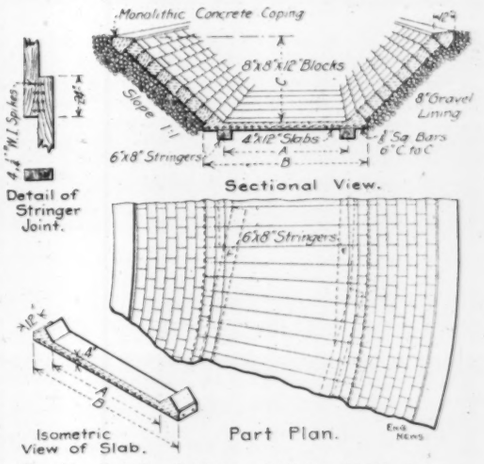


Fig. 11. Details of Lining of Harbor Brook, Syracuse, N. Y.

Surveys and Preparation of Plans for Stream Improvements.

The surveys for the stream improvements included the establishing and permanent referencing of a base line along the banks of each stream; the running of precise level lines nearby; the location of all subsurface and surface structures within a prescribed width along the course of each stream, and the cross-sectioning of each stream at intervals of from 10 to 100 ft. Along

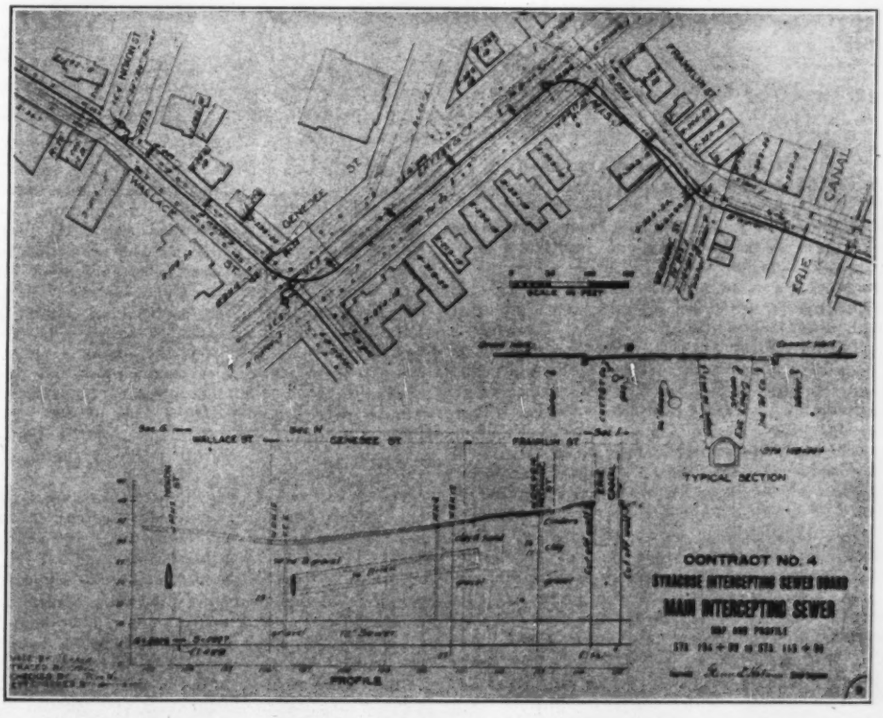


FIG. 12. REPRODUCTION OF PHOTOGRAPHIC REDUCTION OF CONTRACT DRAWING, SYRACUSE INTERCEPTING SEWERS.

(Size of original tracing, within border lines, 17 x 32 ins.; size of photographic reduction, also between border lines, 5⅝ x 7⅜ ins., on a 6 x 8 in. plate.)

the bed of both streams, wash-drill borings were made at intervals of about 300 ft. and samples of the various materials encountered are now available for reference. All of the information gathered, except that relative to the location of contours is shown, so far as practicable, on the contract drawings. In each set there is a sheet devoted to high and low-water surface profiles and to a chart showing the daily or weekly water surface fluctuations at the gaging stations since the date when these were established by the chief engineer.

The adopted standard size of contract tracings is 17 × 22 ins., within border lines. For the convenience of the men associated with the actual construction, and as a matter of economy in the distribution of plans through the mails to prospective bidders, tracings are photographically reproduced on 6 × 8-in. plates, blue prints from which, bound in sets, may be conveniently carried in the pocket or sent through the mails at a nominal cost. Fig. 12 is a direct reproduction from one of these photographs.

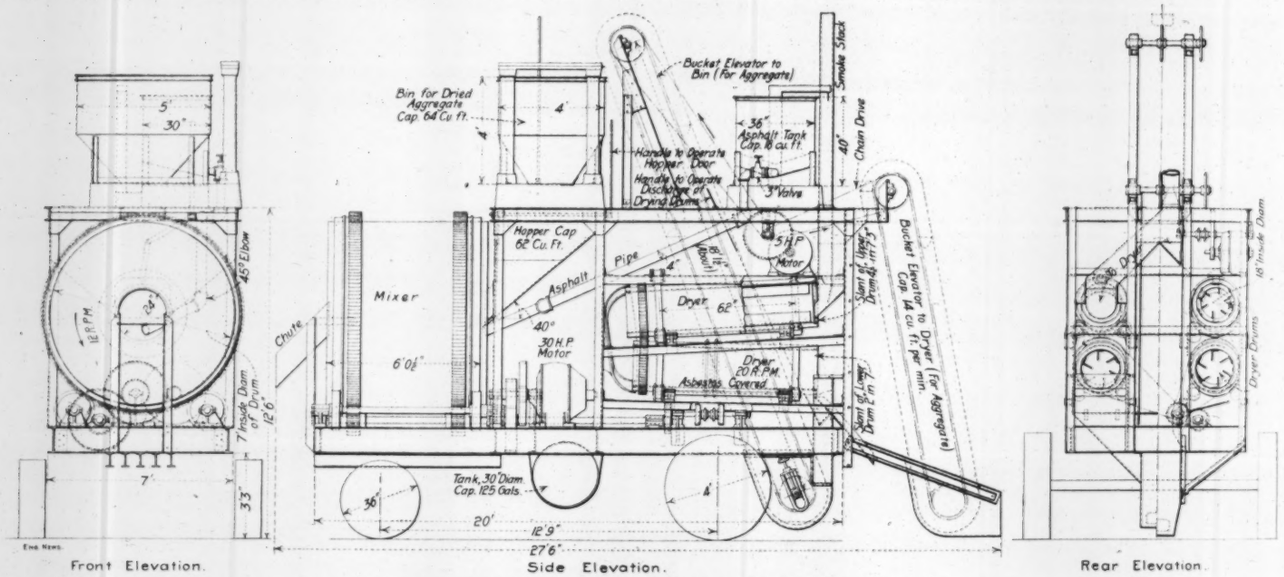
For the photographing of the contract drawings a frame was devised supporting a wide, opaque border around an opening measuring 17½ × 22½ ins. The best results are obtained by photographing with direct rather than reflected light. The lettering on the originals is of such type and size as to be easily read on the reductions. The negatives are printed on blue paper so that the prints are positive, a clean white background being secured. The usual grade of plates or films is not suitable for this photographic work and special plates giving a high degree of contrast are used; otherwise, it is impossible to obtain a white background on the blue prints. By the use of these small prints field reference to the contract drawings is much simplified, a feature to be strongly recommended.

The contractors performing various parts of the work are as follows: Main Intercepting Sewer and Onondaga Creek Improvement, William Fitzgerald, Skaneateles, N. Y.; Harbor Brook Improvement and Intercepting Sewer north of Erie Canal, John Young Contracting Co., Syracuse, N. Y.; Harbor Brook Improvement and Intercepting Sewer south of Erie Canal, Charles T. Hookway, Syracuse, N. Y.; valves for Main Intercepting Sewer, Eddy Valve Co., Waterford, N. Y.; valves for Harbor Brook Intercepting Sewer, Ludlow Valve Co., Troy, N. Y. Several of the smaller contracts have been executed by local contractors.

The Commissioners of the Syracuse Intercepting Sewer Board are Mr. Edward Joy, Chairman, Mr. Henry C. Allen and Mr. John H. Barr. Mr. Glenn D. Holmes, M. Am. Soc. C. E., is Chief Engineer, and Mr. H. J. Hamlin, Secretary. Mr. R. J. Lyon is the Assistant Engineer in charge of the construction of the main intercepting sewer and the Onondaga Creek improvement; Mr. E. D. Wood is the Assistant Engineer in charge of the Harbor Brook Improvement and Intercepting Sewer, and Mr. G. M. Parce, Assistant Engineer, is in charge of the laboratory for testing materials.

A Machine for Preparing Asphalt Paving Compositions.

With the increasing use of asphalt and asphalt-macadam (or asphalt-concrete) paving, several designs of portable plants have been made for preparing the material directly on the work, thus reducing the haul and ensuring a continuous and uninterrupted progress of the work. In the portable plant described below the complete equipment comprises four separate machines and a 10-ton steam roller which serves also to haul the machines from place to place. This equipment includes: (1) a power wagon, supplying current for the several motors which operate the machinery: (2) two asphalt melting wagons, and (3) a machine for drying the aggregate and measuring and mixing the asphalt composition.



A MACHINE FOR MIXING AND PREPARING ASPHALT PAVING.

(Continental Asphalt & Equipment Co., Chicago; Makers.)

The power wagon (weighing about 1½ tons) has a 67-HP. gasoline engine driving a 45-KW. electric generator which supplies current of 110 volts for four motors. Each asphalt melting wagon (weighing 1½ tons empty) has a tank of 1,400 gals. capacity, heated by steam coils. The blocks of asphalt (each one the size of a barrel) are laid upon a grating of steam pipes and thus gradually cut into smaller pieces. Each set of wagons carries a small boiler fired by oil. The tank is fitted with a pump to force the melted asphalt into the measuring tank on the mixer machine for weighing.

The mixer wagon, shown in the accompanying cut, weighs about 12 tons. At the rear of the machine is a bucket elevator by which the aggregate is delivered to a hopper feeding two sets of driers. Each drier consists of two superimposed revolving drums, fitted with blades, as shown; these are 24 ins. diameter and about 7 ft. long. The upper drum is inclined 4½ ins. in its length, and the material falling from it is delivered by a hood into the end of the lower drum which has an inclination of 2 ins. in its length. The drums are enclosed in a casing and are heated from the outside by means of oil burners. The products of combustion pass around the drums and escape by a stack which can be removed when the machine is not at work. The temperature is about 1500° F. at the lower drum and 1000° at the upper drum. The material delivered from the lower drum falls to the bottom of a second bucket conveyor which elevates it to a charging hopper at the top of the machine, for weighing; then it is discharged into the hopper below. The material from the drier may be discharged onto the ground (instead of going to the second conveyor), at the will of the operator. Each conveyor has a capacity of about 1 cu. ft. per min.

The two tanks for the dried aggregate and the liquid asphalt are on top of the machine, and proper proportions of the two materials are delivered into hoppers from which they are delivered by a chute and pipe respectively to a mixer. This mixer is one of the special features of the machine, the mixing being done in a closed revolving drum. This is in fact a concrete mixer adapted to its particular purpose. It runs at about 12 revolutions per minute, and the mixing is done for about eight minutes before the batch is discharged into a wagon for distribution upon the work. A man on top of the machine regulates the supply of material to the tanks and from the tanks to the mixer.

A 30-HP. motor drives one countershaft carrying the two pinions for the mixer drum and another countershaft having sprocket wheels for chains which pass over sprockets on the lower drying drums; the upper drum is driven from the lower one by means of a circular rack on each drum. The lower drum rides on two pairs of carrying rollers; the upper drum has two pairs of carrying rollers and two top rollers which hold it in position vertically. A 5-HP. motor drives a sprocket shaft having chains to the two elevating conveyors.

This mixing machine has a steel framework and is mounted on two pair of wide-tired wheels. It was built by the Koehring Machine Co., of Milwaukee, Wis., to the designs of Mr. H. M. Kingsley, President of the Continental Asphalt & Equipment Co., First National Bank Building, Chicago. It represents the latest development of Mr. Kingsley's system, as the company has operated other less complete machines for five or six years. These machines have been used for work in Rochester, N. Y., Chicago, Milwaukee, and several other cities. They are not built for sale, but are leased to contractors who purchase asphalt from the company. The Continental Asphalt & Equipment Co. has special asphalt of its own, but it also supplies any brand or quality of asphalt so as to enable contractors to meet the requirements of any particular specifications.

Tests of Resistance of Freight Car Trucks When Out of Square.

It is a well recognized fact that car trucks which are out of square tend to increase the rolling resistance of cars, and to cause excessive wear of wheel flanges (and rails). Trucks of this sort are of common occurrence, although considerable attention has been given to devising means of keeping the trucks square. These methods involve rigid and substantial connections between the two side frames, so that the frames are held rigidly together and have no free longitudinal movement in relation to each other. Experiments to determine the difference in frictional resistance of trucks that were square and out of square were conducted last year at the plant of the American Steel Foundries at Granite City, Ill., by Mr. Louis E. Endsley, Associate Professor of Railway Mechanical Engineering at Purdue University. The experiments consisted in running the trucks down an incline and noticing the distances which they traveled on curved and straight track due to their momentum. They are described in a pamphlet issued by the company, and the preface contains the following statement:

> Of the many railway officials who witnessed the experiments, we think it safe to say that there was none who was not impressed with the marked differences in behavior between the two types of trucks. In addition to the differences in the lengths of the runs, perhaps the most impressive thing was the fact that the square truck could invariably be returned to the foot of the incline by two men, whereas with the loose truck from five to seven men were required to push it back around the curve.
>
> While no one seemed to question the results obtained with the trucks themselves, some doubts were expressed as to whether the same conditions obtained with loaded cars and trains. One of the large railways has made a number of tests with loaded cars, and the result of these tests is a striking confirmation of those obtained at Granite City. In order to remove any remaining doubt in the minds of those who question the results, it only remains to make dynamometer tests with trains properly equipped to give the desired information.

The experimental track consisted of a steep incline having a drop of 36 ft. (grade not stated) followed by a 30-ft. tangent, a curve of 262 radius (303.3 ft. long, 4½ ins. superelevation), a tangent of 257 ft., and an incline having a vertical rise of 20 ft. The gage was widened to 4 ft. 9 ins. on the curve, and the grade was 1.28% on the curve and 0.38% on the 257-ft. tangent. A 600-ft. level tangent also ran from the foot of the main incline, and ended in an incline of 25 ft. rise. The tests were made with different kinds of trucks, including six specially constructed test trucks and 18 trucks taken from cars in regular service on several railways. All of these (except one) were from 100,000-lb. cars. Their weight was from 5,140 lbs. to 12,520 lbs., but in most cases the weight was increased to 65,000 or 22,000 lbs. by means of a cast-iron loading block. The shoes and brake beams were removed to eliminate any brakeshoe friction on the wheels. The incline was equipped with an electric hoist to haul the trucks, which could be released at any point by a trip.

In anticipation of a test, the truck was weighed carefully, after which it was placed upon the experimental track and pulled up the incline to the desired height, being released a number of times until the distance the truck would run before stopping became constant. When the testing was on the curved track five record runs were then made, from which the average velocity at the beginning and the end of the curve was determined. The same method was employed in obtaining the velocity on the tangent track at the end of the curve, except that as this tangent was so short and the loss in velocity so small, the average of ten runs was used. The testing on the 600-ft. tangent track (which was level) was conducted for four to six hours by alternately running the truck loose for two runs and square for two runs. The average distance of all the runs loose and of all the runs square was taken as the performance of the truck in each condition. Most of the tests on the curved track were conducted by raising the truck to a height which, when released, would give it a velocity of approximately 19 m. p. h. at the foot of the incline. All of the tests on the 600-ft. tangent track were conducted at an initial speed of approximately 23.5 m. p. h.

The velocity at any point was determined by means of an electric chronograph. The apparatus consists of a drum driven at any constant velocity by a properly geared centrifugal governor; two pens, mounted upon a transfer table of the machine, were driven by means of a screw and drew spiral lines around the drum as it rotated. One of these pens was connected to a clock, by means of an electric current, which caused it to beat half seconds. The other pen was connected with a track circuit, and as the truck passed the contact points on the track this pen recorded it upon the drum. These contact points were placed 20 ft. apart, and the time that it took the truck to go this distance was obtained from the record made upon the drum. From this the velocity in feet per second was computed.

Two methods were used in determining the movement of one side frame with respect to the other. One method consisted of measuring the increase and decrease in length of the diagonal from the top of one journal box to the top of the other. This was done by having a wooden arm (carrying a pencil at one end) pivoted to the corner casting on the truck and reaching diagonally across to the other corner. A suitable board was fastened to the latter corner, to which a card was attached. When the truck was about to be started down the incline, the pencil was placed in contact with the card and lightly held there by a rubber band. As the truck ran around the curve, this pencil would record the increase or decrease in length of the diagonal. Whether the diagonal was lengthened or shortened depended upon the direction in which the truck was running. The diagonal upon which this measuring device was arranged was such that if the truck was going out from the incline, this diagonal distance would be increased. If the truck was coming back towards the incline, this diagonal would be shortened. As the pencil was left in contact with the paper during a complete run of the truck, that is, during the time of the truck running out to the further incline and back to the first incline, the total movement of the pencil upon the paper recorded the difference between the maximum and minimum length of the diagonal.

This motion recorded on the diagonal is only 74% of the total movement of one side frame with respect to the other. This reading of 74% was obtained by taking cards simultaneously upon the diagonal as described above and upon an apparatus constructed at the end of the truck. The second arrangement consisted in having two bars of iron fastened on top of the journal boxes. One of these bars had a 90° horizontal bend which caused it to reach across the front of the truck. It carried a suitable board on which could be fastened a card. The other bar (projecting straight in front of the side frame.—Ed.) constituted a support for the free end of the first bar and was also equipped with a suitable arrangement for holding a pencil. This arrangement recorded the exact motion of one side frame with respect to the other. Half the length of the line, as drawn upon the paper as the truck passed around the curve and back again, gave the amount to which the truck went out of square in going around the curve.

It was found as the trucks would go out of square that the flanges of one wheel would not be in line with the flanges of the wheel in front of it. In one case a straight edge placed against the back of the rim of the rear wheel was 2¼ ins. away from the rim of the leading wheel. This indicates to what extent the loose truck may be out of alinement when passing around a curve.

In order to determine the difference in contact between wheel and rail for trucks loose and square, the rail was whitewashed for some distance and the truck (with a new wheel.—Ed.) was run over this part of the rail and allowed to stop on the whitewashed part and then run back. When the truck was run square there was only one broad point of contact between the wheel and the rail, and the throat of the wheel was in contact with the rail. On the other hand, when the truck was run loose, there were two points of contact; one on the top and the other on the side of the rail. The distance between these two points of contact was approximately ¼-in. and the point of contact between the side of the rail and the flange of the wheel was 1⅝ ins. ahead of the point of contact between the top of the rail and the tread of the wheel. It is evident that this contact between the wheel flange and the side of the rail is a sliding contact. This difference in the contact between the wheel and the rail for trucks loose and trucks square no doubt accounts for the increased resistance for a loose truck over a square truck when on a curve.

TABLE I.—RESISTANCE OF FREIGHT CAR TRUCKS ON A CURVE OF 262 FT. RADIUS.

Square trucks — Ave. speed on curve. Entrance, m. p. h.	Square trucks — Ave. speed on curve. End, m. p. h.	Square trucks — Resistance corrected for level track, lbs. per ton	Trucks loose or out or square — Ave. speed on curve. Entrance, m. p. h.	Trucks loose or out or square — Ave. speed on curve. End, m. p. h.	Trucks loose or out or square — Resistance corrected for level track, lbs. per ton.	Trucks loose or out or square — Total movement of side frames, ins.
23.07	18.27	22.69	16.21	7.98	20.78	0.65
19.00	12.64	23.33	24.00	19.15	23.32	0.65
16.83	9.37	21.85	16.15	3.62	32.00	3.78
13.67	7.50	20.35	18.97	10.68	34.30	3.78
16.25	8.08	20.85	23.30	17.09	32.86	3.78
17.25	10.05	20.23	19.00	9.82	39.03	4.56
19.39	13.22	23.58	19.31	10.04	37.72	4.56
23.79	18.75	24.79	23.42	16.71	40.32	4.56

The work accomplished on the 600-ft. tangent track shows that the resistance on a straight track for non-mated wheels is affected by the condition of the truck, a square truck having less resistance than a loose one. This no doubt can be explained by the fact that each of the trucks tested on this straight track had the wheels on one side of the truck larger than those on the other, and it did not make any difference which way the truck ran, the small wheel always crowded the rail. This was caused by the fact that the larger wheel attempted to get ahead of the smaller one and thus forced the truck over to the small wheel side. The attempt of the large wheel to go ahead of the small wheel caused the loose truck to get out of square, which, no doubt, accounts for the increased resistance offered by the loose truck.

Conclusions: (1) From the data obtained from the curved track it is obvious that a truck which is constructed in such a way that it will remain square and hold the axles radially with the curve, will go around the curve with considerably less resistance than a truck otherwise constructed.

(2) From the tests conducted upon the 600 ft. tangent track it would seem that where the wheels of the truck are not well mated, a method of construction which will hold the axle perpendicular to the track will tend to slightly reduce the resistance.

In Table I. are given some of the results of the tests in running the trucks down the incline and onto the curved track (262 ft. radius). The resistance was calculated for various degrees of curvature, and the percentage of reduction in resistance of a square truck as compared with a loose truck ranged from 7.9% for a 1° to 36.5% for a 26° curve. In runs on the 600-ft. tangent, the average distance traveled was 4,432 ft. for the loose truck (3,928 to 5,097 ft.) and 4,469 ft. for the square truck (3,957 to 5,254 ft.). The percentage in favor of the latter was from 0.18 to 3.07%, with an average of 1.06%.

To show clearly the relation between the curve resistance and the amount that the truck is out of square, the results of the tests were divided into five groups classified according to this distortion or movement of the truck frames. The averages were then taken for the several groups, with results as shown in Table II.:

TABLE II.—CURVE RESISTANCE FOR TRUCKS OUT OF SQUARE.

Truck out of square, ins.	Resistance, lbs. per ton.
Less than ½	24.68
½ to 1	26.74
1 to 1½	34.74
1½ to 2	36.88
Over 2	39.78
Ave. for all trucks out of square	38.33

THE IMPROVEMENT OF THE SHERIDAN ROAD (or Sheridan Drive) extending north from Chicago along the lake shore is to be undertaken by a private body organized by a number of leading citizens under the name of the Sheridan Road Improvement Association. The length of the road which it is now proposed to improve is about 20 miles, extending from Chicago to Lake Forest. A traffic census is to be made, and an engineer is now investigating the present conditions in order to report upon the character of the work needed and its probable cost. As there is a very heavy traffic of automobiles, it is proposed to build a road of a character to carry this traffic with a minimum of repair and maintenance expense. It is proposed to ask the several towns through which the road will pass to contribute towards the cost, and to raise the balance of the money by private subscription. It is proposed also to prepare rules for traffic regulation and to request the several towns to adopt and enforce these rules. It is not expected to have the work done by contract, as it is considered that the Association itself can do the work more economically. The preliminary work will take considerable time, and it is not expected that any construction will be done this season, but that active work will be commenced early in 1912. Mr. Edwin L. Lobdell is President of the Sheridan Road Improvement Association; Mr. F. J. Scheidenheim is Secretary, and Mr. D. H. Burnham is Chairman of the Executive Committee.

Recent Improvements in Single-Phase Motors.*

By W. A. LAYMAN.†

Engineers have been aware that there existed a strong demand for improvement in the commercial forms of single-phase motors in two directions:

(1) A simplification of the mechanical structure of the best form of the constant-speed, single-phase motor and an improvement of its power-factor.

(2) The development of a high-power-factor, adjustable-speed, single-phase motor comparable to the well-known adjustable-speed, shunt-wound, direct-current machine.

The company with which I am associated has diligently endeavored to meet these more stringent demands of the modern market and has succeeded in developing a new form of constant-speed, and an adjustable-speed, single-phase motor, meeting substantially all of the above requirements. It is the purpose of this paper to describe briefly the performance characteristics of these new motors.

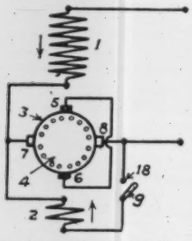


Fig. 1. Diagrammatic Arrangement of New Single-Phase Motor; Patents of V. A. Fynn.

CONSTANT-SPEED MOTOR.—The constant-speed single-phase designing work of the company's engineers has, in general, been based upon two fundamental assumptions: (1) That good starting performance required the use of a commutator. (2) That the commutator must be relieved of the greater part of its duty on attaining full speed, thus making the working condition of the rotor the practical equivalent of that obtaining in the well-known squirrel-cage rotor of the polyphase motor.

It was in following these principles that the well-known Arnold type of single-phase motor, starting as a repulsion, and running as an induction motor with commutator completely short-circuited, was produced.

In developing the improved form of constant-speed motor, the same principles of design have been adhered to by the company's engineers. The new motor is, briefly described, as follows (see Fig. 1):

The stator, or field construction, corresponds closely to that heretofore employed, with the exception that two windings are used instead of one. The main stator winding (1) produces the initial field magnetization as heretofore; the auxiliary winding (2) controls the power factor or "compensates" the motor.

The main structural departure is in the rotor, the construction of which is more clearly indicated in Fig. 2. Here again two windings are employed. The main or principal winding (4) is of the usual well-known squirrel-cage type and occupies the bottom of the rotor slots. The second or auxiliary winding (3) is of the usual commutated type, is connected to a standard form of horizontal commutator and occupies the upper portion of the rotor slots. Between the two is placed a magnetic separator in the form of a rolled-steel bar. Two sets of brushes are provided, as indicated in Fig. 1. The main pair of brushes (5-6) is placed in the axis of the main stator winding (1) and is short-circuited. The auxiliary pair of brushes (7-8) is placed at right angles to the axis of the main stator winding and is connected in series with it at starting.

Fig. 2. Cross-Section of Rotor Slot in Fynn Motor.

The auxiliary stator winding (2) is permanently connected to one auxiliary brush (7), and is adapted to be connected to the other auxiliary brush (8) by means of the switch (9).

The purpose of the peculiar rotor construction illustrated in Fig. 2 and of the brush arrangement and connections shown in Fig. 1 is to accentuate, at starting, the effect of the squirrel-cage along the axis (5-6) of the main stator winding (1), while suppressing it as far as possible along the axis (7-8) at right angles to (1). The magnetic separator placed above the squirrel-cage winding (4) tends to suppress the effect of that winding along all axes, by making said winding less responsive to outside inductive effects. But the influence of said separator is nullified along the axis of the main stator winding by the presence of the short-circuited brushes (5-6), while no means are provided for nullifying its effect along the axis at right angles to that of the main stator winding. Thus the main stator winding (1) will be able to induce heavy currents in both rotor windings because of the short-circuited brushes in the axis (5-6), and in spite of the magnetic separator, while the rotor windings (3), connected in series with (1), will not be able to produce heavy currents in the squirrel-cage winding (4) along the axis (7-8), because of the magnetic separator between (3) and (4), which shunts or sidetracks the inducing magnetic flux.

The mode of operation may be generally described as follows: At starting, switch (9) of Fig. 1 is open, the commutated winding (3) along the axis (7-8) being connected in series with the main stator winding (1) and across the mains. The winding (1) induces a large current in the rotor windings (3) and (4) along the axis (5-6), and the winding (3) produces a large flux along the axis (7-8). The rotor currents in the main axis co-acting with the flux threading the rotor along the auxiliary axis yield the greater part of the starting torque. As the motor speeds up, the squirrel-cage gradually assumes those functions which it performs in the ordinary single-phase squirrel-cage motor, developing a magnetic field of its own along the axis (7-8) and a correspondingly powerful torque, which increases very rapidly as synchronism is approached, but falls suddenly to zero at or near actual synchronism. It is known that the magnetizing currents circulating in the bars of the squirrel-cage of a single-phase motor have, at synchronism, double the frequency of the stator currents; the fluxes they produce must therefore also be of double frequency. Now, the magnetic separator is made of solid steel, and, while this separator forms a sufficiently effective shunt for the fluxes of line frequency induced from the stator, it is quite ineffective as a shunt for the double-frequency fluxes produced by the rotor. As far as the squirrel-cage is concerned, the effect of this magnetic separator diminishes with increasing speed, and at synchronism the machine operates practically in the same manner as if said magnetic separator did not exist at all.

The speed-torque curve of this machine is therefore mainly composed of two torques. The one is due to the interaction of the commuted and the squirrel-cage windings in the main axis with the commuted winding in the auxiliary axis; this torque is large at starting, and diminishes with increasing speed. The other is due to the interaction of the main stator winding and the squirrel-cage winding; this torque is *nil* at starting, but increases very rapidly beyond a certain speed. The net result is a speed torque curve which in the main is a rising one, reaching a maximum just below synchronous speed, and becoming *nil*, or nearly so, just above synchronism.

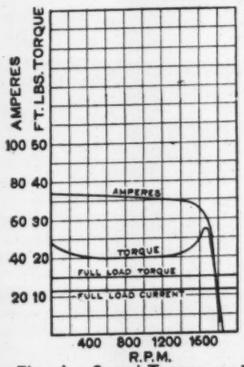


Fig. 4. Speed-Torque and Speed-Current Curves of a 5-HP. 1800-r. p. m. 60-Cycle, Four-Pole, Single-Phase Motor.

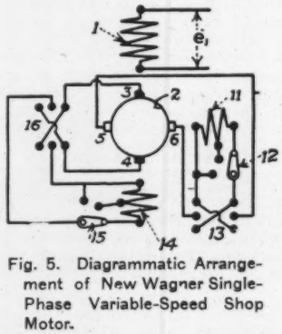


Fig. 5. Diagrammatic Arrangement of New Wagner Single-Phase Variable-Speed Shop Motor.

In mechanical structure, the new motor is remarkably simple. It gives little or no outward evidence of unique construction, and internally there are no mechanical features complicating the motor in any degree. A small automatic centrifugal switch, provided on the outer extension of the rotor shaft, is used in place of the switch (9) of Fig. 1; it serves to connect the compensating winding (2) to the brushes (7-8) after a sufficient speed has been reached. This automatic switch is not essential to the operation of the motor in any respect, but does serve the purpose of improving the power factor and of slightly improving the efficiency in the running condition. Should the automatic switch fail to operate, there would be no outward evidence of such failure, and the motor would continue to carry its full load at the proper speed and without the slightest interruption.

Several beautiful features of the motor, with respect to durability and reliability, are as follows:

(1) A large portion of the rotor currents are carried by the squirrel-cage winding, in normal operation thus imposing light-load service on the commutator.

(2) The close proximity of the squirrel-cage to the commutated winding suppresses, to a large extent, the short-circuit currents which tend to flow in the individual coils of the commutated winding as they pass under the brushes. This again very greatly lightens the commutator service.

(3) The employment of the squirrel-cage secures a remarkably constant speed at all loads.

(4) The squirrel-cage absolutely prevents the motor from running away, or "racing."

As indicating how reliable the "BK" motor is in practical service, it may be stated that trial motors in regular shop service have been operated until all the brushes were almost entirely worn away and were making but slight contact with the commutator. Still, the motor has continued to perform at constant speed and with thorough reliability in every respect. This is explained by reason of the fact that in the running condition the vital working elements of the motor are the main field winding (1) and the squirrel-cage rotor winding (4),

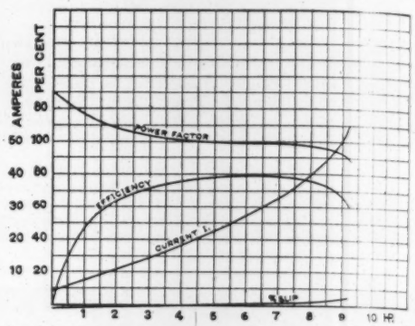


Fig. 3. Normal Running Performance Curves of a 5-HP., 1800-r. p. m., 60-Cycle, Four-Pole, Single-Phase Fynn Motor.

The new motor yields a starting torque of sufficient magnitude for all ordinary purposes, and goes on increasing this torque with increasing speed, thus insuring rapid acceleration. The motor will "pull through" any load it can start. The new motor can, when specially desired, be designed to give a starting torque from two to three times the normal running torque. It is particularly interesting to note that the power-factor curve of the new motor, under running conditions, is leading at light loads, and substantially unity from one-half to 50% overload. The installation of such motors would be of material assistance to the average central station, in that these machines would help to improve the average lagging power factor, which, under present conditions, is very low. This beneficial effect of the new motor on central stations can be intensified by overcompensating these machines and thus causing them to take a heavy leading current at all loads. Larger and somewhat less efficient motors, for a given output, would naturally be required in such cases.

The manufacturers are placing a limited number of these motors in commercial service, the design having just been reduced to commercial form. The motor is built under the patents of Mr. V. A. Fynn.

ADJUSTABLE-SPEED SINGLE-PHASE MOTOR.—In the last few years, inventors developing this class of apparatus have, from time to time, freely published discussions of their theoretical work. Among those actively engaged in bringing this type of motor to a successful commercial solution have been Mr. V. A. Fynn, of England; Prof. E. Arnold, of Germany; and Mr. J. L. la Cour, of Sweden. A large number of patents of the broadest scope have been issued to these gentlemen on this form of machine, and our company has undertaken to develop commercial motors under these patents.

A 3-HP. (nominal-rating) motor, showing the flexibility of speed adjustment, and indicating that this type of motor will yield substantially the same results as a shunt-wound direct-current motor, may be mentioned. This unit is capable of adjustment in speed between the limits of 750 and 2,250 revolutions, yielding from 2 HP. at the lowest speed up to 5 HP. at the highest speed. The number of positive steps of control may be as many as desired within reasonable limits, and is commonly six.

Under the normal conditions of machine-tool operation, which will be one of the most useful forms of application of this new motor, 5 to 8 steps in speed adjustment will usually suffice. These may be readily supplied in any size of motor. Usually, in machine-shop

*From a paper read before the annual convention of the National Electric Light Association, New York, May 30.

†Wagner Electric Manufacturing Co., St. Louis, Mo.

practice a 2 to 1 or 3 to 1 speed-adjustment range will be entirely satisfactory. Such range can be readily taken care of by this new single-phase motor.

The mechanical structure of this motor is in appearance very similar to that of the ordinary single-phase motor. Its windings and connections, in their simplest form, are shown in Fig. 5. The rotor is provided with a commutated winding (2) connected to a commutator on which rest two sets of brushes, located as in the

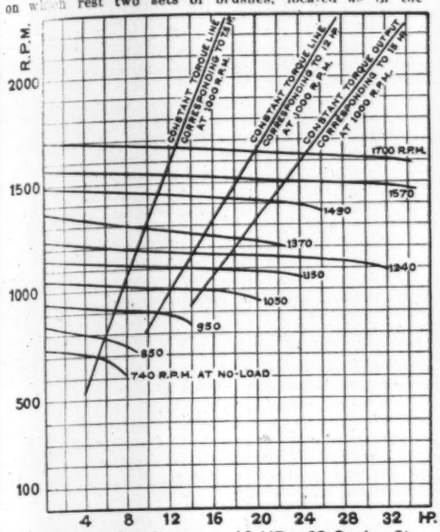


Fig. 6. Test Results on a 12-HP., 60-Cycle, Six-Pole, 220-Volt, Variable-Speed, Single-Phase Motor.

constant-speed motor above described. The set of brushes (3-4) carries the working currents; the set (5-6) carries the exciting and compensating currents.

The main winding (1) provides the initial magnetization. The winding (14) is made use of for regulating the armature circuit, while the winding (11) serves to regulate the field or exciting circuit. Both circuits are regulated by changing the number and the direction of the effective turns of the windings (11) and (14). The number of turns is regulated by the switches (12) and (15), while their direction relative to the brushes to which they are connected is controlled by the reversing switches (13) and (16). In actual structure the motor is simple, efficient and reliable. It has come into practical commercial use in some of the European countries, and it is expected that during the ensuing year it will gradually come into commercial use in the United States.

A set of test results obtained on a motor designed for

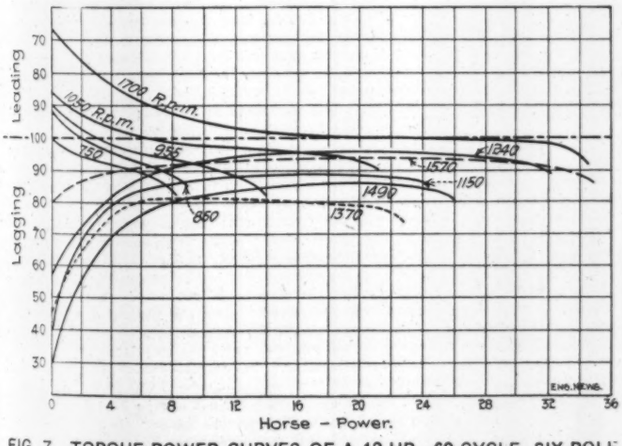


FIG. 7. TORQUE-POWER CURVES OF A 12-HP., 60-CYCLE, SIX-POLE, 220-VOLT, VARIABLE-SPEED, SINGLE-PHASE MOTOR.

12 HP. at 1,200 r.p.m., and a speed range of 2 to 1, give a good idea of the possibilities of such machines. In Fig. 6 appear the speed curves of this motor on various steps of the controller. The small percentage of slip between no load and maximum load, on each step, is one of the very interesting phases of the performance of this motor. In Fig. 7 are similarly shown the power-factor curves for each of these speeds. The very high power-factor of the motor under all these operating conditions is especially noteworthy. The efficiency of this motor is fairly constant for all speeds within the intended working range of the machine, *i. e.*, from 56 to 78.5% between 850 and 1,700 revolutions.

Troubles With Hot Water Piping and Hot Water Supplies in Buildings.*

By GEORGE C. WHIPPLE,† M. Am. Soc. C. E.

When one considers the fact that most houses that are supplied with running water are equipped with hot water services as well as cold, and that a very large percentage of domestic water consumption is drawn from the hot water taps, it is rather surprising that the quality of hot water has been discussed so seldom by water-works engineers. Perhaps this is because hot water is almost never used for drinking; perhaps it is because such troubles as have arisen have been deemed to fall within the province of the plumber rather than that of the engineer; perhaps it is because the troubles have been so intermittent, so localized and so various in character that general causes have not been sought for. Whatever the reason may be for the poverty of engineering literature on the subject, it has been a matter of common knowledge for many years that the heating of water and its passage through boilers, tanks and pipes of various metals often has a marked effect upon its quality. Conversely, hot water often has a material influence on the structures used for heating and carrying it.

The hot water troubles usually met with are not of a hygienic character, but are physical. They are largely problems of corrosion. Yet they are practical problems, and in a number of instances that have come within the observation of the writer, they have been of a serious character. When, with the cold water satisfactory, the hot water becomes too rusty to be used for bathing, when marble bowls become discolored, when clothes in the laundry become stained, when pipes become choked with iron rust, or become so weakened through corrosion that they have to be replaced, when tenants leave their apartments and when even the most long-suffering citizens complain of the water service, the situation well deserves the name "red water plague" that has come to be applied to it. And when such phenomena follow a change in the water-supply or changes in the method of heating and distributing the hot water, the subject is one worthy of serious investigation by water-works engineers.

TEMPERATURE REQUIRED FOR DOMESTIC SERVICE.—The hot water required for domestic service need not ordinarily have a temperature above 140°F. For most purposes hot water as it is used has a lower temperature than this. In apartment houses not provided with laundries and where all the washing is done in set tubs, higher temperatures are the rule, and they often run well above 150°—in fact, sometimes the tap water seems to be almost boiling. The range of temperature observed in hot water systems therefore varies all the way from the temperature of the cold supply nearly up to the boiling point.

QUANTITY OF HOT WATER USED.—Very little is known about the quantity of water that passes through the hot water systems of our houses, but it certainly is a substantial proportion of all the water used for domestic purposes, often a quarter or a third of it, and sometimes more. Through the courtesy of Mr. E. E. Lochridge, Chief Engineer of the Water Department of Springfield, Mass., the following figures [table omitted] are presented, showing the consumption of hot water in an apartment house in which reside 14 families, comprising 50 persons. These figures indicate that during the two winter months covered by the measurements, about 42 per cent. of the water used passed through the hot water system. [30.6 gals. of hot as compared with 42.9 gals. of cold water.] The amount of hot water used is greater in winter than in summer.

METHODS OF HEATING.—In private houses the source of heat is commonly the kitchen range, which is provided with a cast-iron water-back, or water-front, or with brass pipes laid around the fire box. Sometimes the furnace is used for this purpose during the winter. Recently gas heaters have come into extensive use. These consist of a coil of copper pipe surrounded with a metal jacket, the water flowing through the pipe and the heat from the gas flame impinging on it. In apartment houses and hotels special cast-iron heaters are provided for this service alone, or the water is heated by steam coils placed inside the storage tank. The apparatus is placed in the cellar and cared for by the janitor. In all cases the hot water system includes a storage tank, which in private houses is commonly known as the kitchen boiler. In private houses the hot water service is somewhat intermittent, but in apartments a constant supply is supposed to be maintained at all times, although during the night it is common to bank the fires and reduce the heat. [Here come illustrated descriptions of the various methods of heating and distributing water.—Ed.]

MATERIALS OF CONSTRUCTION.—The water-backs and water-fronts in kitchen ranges are made of cast-iron. The pipes in ranges are usually of brass. In gas heaters copper pipes are used. The special heaters used in apartment houses are made of cast-iron. In the tanks heated by steam the pipes are made of brass, wrought-iron or steel.

Formerly the kitchen boilers were quite generally made of copper and this metal is still used somewhat where the water is soft and where the pressures are low, as in the tank system. For the pressure system stronger boilers are required, made of wrought-iron or steel, most commonly of galvanized steel. The storage tanks used in apartment houses are also made of wrought-iron or steel. In high-class installations they are galvanized.

The distribution pipes are made of brass, lead and galvanized wrought-iron or steel. Brass is used in the best installations and is necessary for some waters. With other waters galvanized wrought-iron or steel gives satisfaction and is cheaper. Lead is now used but little on account of its increased cost. Not infrequently a combination of metals is used, brass being employed for the pipes between the range and the boiler and wrought-iron or steel for the service pipes between the boiler and the separate fixtures. Tin-lined lead pipe is used to a limited extent, but Weston has shown that the tin lining fails to protect the lead from corrosion. In some places the alloy of lead and tin is said to be used. Altogether, perhaps the most important fact to be reckoned with is the greatly increased use of steel pipe during the last few years.

RUSTY WATER.—Very few of the red water troubles are caused by the iron naturally present in the water or by the action of the water on the street mains, but rather by the corrosive effect of the water on the tanks and service pipes through which the water flows.

THEORY OF CORROSION.—According to the modern and now generally accepted theory, the corrosion of iron by water and the formation of iron rust requires (1) the presence of hydrogen ions in the water, and, (2) the presence of dissolved oxygen. Hydrogen ions are electrically charged atoms of hydrogen. All acids form them by dissociation. Whenever they are present in solution that solution possesses acid properties. They attack the metallic iron, which is dissolved in a ferrous condition. The oxygen dissolved in the water then oxidizes this ferrous iron and iron rust is formed. Under certain conditions this precipitates at once. Under other conditions it apparently exists in a colloidal state; that is, in an extremely fine state of subdivision with its particles electrically charged, and precipitates only when this electrical charge is neutralized. Very little is known about this phenomenon. Certain substances tend to prevent the precipitation of colloids. Thus, peaty organic matter tends to prevent the precipitation of iron.

Iron has a natural tendency to dissolve in water as the hydrogen ion is always present in some degree. Pure water, therefore, by its dissociation tends to act as a weak acid. Even in the purest distilled water there is a splitting up, or dissociation, of some of the molecules of water into the hydrogen ion and the hydroxyl ion. Distilled water therefore acts as an acid. Iron will be dissolved, and rust will form if oxygen is present. Whatever increases the number of hydrogen ions in water increases its corrosive power. Acids do this to a marked degree. Whatever decreases the hydrogen ions reduces the corrosive power. Alkalis do this.

A further conception of the phenomenon of iron rusting is that often referred to as "the electrolytic theory of corrosion." According to this theory a sort of battery action takes place in the water and a current of electricity is set up between the metallic iron at one spot and some other metal or some impurity in the iron at some other neighboring spot.

The increase of other metals also affects the corrosion of iron by increasing the difference of potential, and therefore the strength of the electrical currents. This is termed galvanic action. The metals act differently in regard to the direction of the electrical currents between them and iron. Some cause the positive current to flow towards the iron, and some away from it; that is, some hasten the corrosion of iron and some retard it. The common metals are arranged in the following order of what is called the potential series: Aluminum, manganese, zinc, iron, nickel, tin, lead, hydrogen, copper. Each metal tends to protect the other metals in the series below it from going into solution, but in doing so it itself tends to dissolve. Thus, zinc protects iron. On the other hand, copper acts in an opposite way, and increases the solution of iron.

The water supplies with which the red water plague has been observed may be classified as follows:

*Condensed from a paper read before the American Water Works Association, Rochester, N. Y., June 8, 1911.

†Consulting Engineer, 103 Park Ave., New York City.

Class 1—Very soft ground waters.
Class 2—Waters in which the chlorides or the free carbonic acid are high as compared with the alkalinity.
Class 3—Very soft surface waters that are relatively high in color and contain peaty, organic matter and free carbonic acid.
Class 4—Relatively soft waters, especially high-colored waters, with which sulphate of alumina is used as a coagulant but which are not overdosed so far as the alkalinity is concerned.
Class 5—Waters overdosed with sulphate of alumina so as to render them acid.
Class 6—Waters containing originally excessive amounts of iron.

SOFT GROUND WATERS.—Some of the ground water supplies on Long Island are troubled with rusty hot water. These waters are invariably soft. In some cases the chlorine is rather high, varying from 10 to 25 parts per million. The dissolved carbonic acid is also high and dissolved oxygen is present. Other waters on Long Island taken from neighboring wells and similar in character, except that the hardness is high, may cause little or no rusty water. In some, oxygen is lacking.

WATERS IN WHICH THE CHLORIDES ARE HIGH BUT THE CARBONATES LOW.—Many waters of this class exist along the East Atlantic Coast. As an example, the water supply of a village a few miles north of Camden may be referred to. An analysis of this water, made on April 18, 1905, showed that the chlorine was high but that the carbonates were low. The water as taken from the wells contained an insignificant amount of iron, but the water in the houses was at times more or less rusty.

SOFT COLORED WATERS.—It is a well-know fact that soft surface waters corrode the metals used for service pipes. This matter has long received attention in connection with the subject of lead poisoning. The soft, peaty water-supplies obtained from the English moorlands act on lead pipes, sometimes to a serious extent. In a number of English cities, such as Birmingham, Sheffield, and elsewhere, lime is added to the water to prevent injury to the public health from lead poisoning and to avoid the inconveniences attending the corrosion of other metals.

In 1900 Clark and Forbes, chemists of the Massachusetts State Board of Health, published a report on the corrosion of service pipes in which the effect of dissolved carbonic acid was found to be of controlling importance. The action was found especially severe when the carbonic acid was high and the water soft.

Rusty hot water has been observed to some extent in New York City. The Croton water is somewhat harder than the waters of New England, although it cannot be fairly classed as a hard water. Galvanized iron and steel pipes are largely used for the hot water services. Dr. Ira H. Woolson has recently called attention to the rusting of both iron and steel pipes in various public bath-houses of the city (Eng. News, Dec. 8, 1910). This has also been noticed in some of the larger hotels and to some extent in private residences. Generally speaking, however, the New York City water has not caused serious trouble in this way.

In many New England cities supplied with soft surface water, experience has led to a very general use of brass and lead pipe for hot water service, and iron pipes have been avoided. Occasionally in recent years trouble has been experienced where galvanized iron or steel pipes have been substituted. This has been the case in Springfield, Mass., where rusty water troubles have occurred to an increasing extent during the last few years.

Conversely, it is also a fact that in localities where the public water supplies are hard, galvanized-iron and steel pipes have been satisfactorily used for hot water supplies instead of brass. This is true of London, where the water supply is hard, whereas in the cities of Middle England, where the water supplies are softer, such pipe is avoided.

SOFT WATERS TREATED WITH ALUM, BUT NOT OVERDOSED.—It is to the waters of this class especially that the attention of engineers has been drawn during the last few years, not only because of the seriousness of the rusty water troubles that have occurred, but because, as a result of them, there has been growing up a prejudice against the use of alum as a coagulant. It should be said at the outset that such an inference should not be too hastily drawn, but judgment should be reserved until the matter has been considered broadly in all its aspects.

One of the instances with which the writer is most familiar is that of the red water plague at Watertown, N. Y., that has occurred since the introduction of a mechanical filter in 1905. The supply of this city is taken from the Black River. The water is an especially difficult one to treat, partly because of its high color, partly because it contains organic matter resulting from the pollution of the river by the wastes of pulp mills and partly because of its relatively low and variable alkalinity. On account of the high color and the fluctuations in the amount of organic matter and alkalinity that suddenly occur without warning, it is necessary to apply rather large amounts of sulphate of alumina. The following figures will serve to give an idea of the character of the water treated and the amount of alum that has been used:

Year.	Color—Raw water.	Color—Filtered water.	Alkalinity—Raw water.	Alkalinity—Filtered water.	Alum used grains per gal.
1905.....	69	10	39	19	2.07
1906.....	62	9	39	22	2.09
1907.....	69	6	28	12	2.33
1908.....	65	7	31	14	2.34
1909.....	67	8	30	12	2.23
1910.....	70	12	28	10	2.36

Not long after the filter was put into service, complaints arose throughout the city that many of the copper-lined water-closet tanks were giving out through corrosion along the seams. This appeared to be due in part to a slightly increased conductivity of the water resulting from the alum treatment, but also to the fact that the filtered water was much clearer than the raw river water that had been previously used; so that the tanks, instead of being covered with a thick layer of slime, as they had been, were cleaner and there was greater exposure of the metal to the circulating water, a condition favoring corrosion through galvanic action. At the same time it was also found that the hot water in many of the houses was becoming rusty—so much so that in various instances the water was too dirty to be used for bathing. This was not generally true throughout the city but was noticed more in some places than in others, being especially troublesome in some houses of recent construction.

A study of the matter at this time showed that the water from the filter as it left the plant contained a very small amount of iron and that the cold water in the city contained very little more than at the filter. Such an increase in the amount of iron in water passing through the city mains is not an unusual one.

Further evidence that the corrosion of the city mains was not serious was obtained by flushing various hydrants throughout the city. The amount of rusty water drawn at such times was found to be not much greater than that normally observed.

When samples of hot water were compared with samples of cold water, however, it was found that in almost every case the hot water was more highly colored and contained more iron than the cold water. Thus, in May, 1908, hot water samples were found to have colors between 50 and 300, while, at the same time, the water as it left the filter plant and as it flowed from the cold water taps had a color of less than 5. In some instances the iron came from the hot water faucets as flakes of rust, that would settle in a tumbler and cause a thick-reddish deposit on the bottom.

The red water plague was particularly severe during the winter of 1907-1908 at a time when the amount of alum used was rather large and when the alkalinity of the filtered water was low. It should be noted here that the application of the alum to the water at the Watertown filter is watched with great care. The plant is in charge of a chemist and samples of raw and filtered water are collected and analyzed four times each day and have been ever since the plant was started. These analyses show that the filtered water has always been alkaline to methyl orange, or erythrosene. At times, when the alkalinity of the raw water has been low it has been necessary to use soda ash in order to provide alkalinity for the decomposition of the alum.

These same rusty hot water phenomena have been observed in many other places besides Watertown. [Mention was here made of the water taken from the Passaic River at Little Falls, N. J., to supply Paterson and other places; of the supply of Burlington, Vt., and Charleston, S. C. All three supplies are subjected to mechanical filtration.—Ed.]

A more recent instance of the red water plague is that which occurred at Springfield, Mass., in the spring of 1910. This trouble is said to have begun several years before this when the supply of the city was taken from the Ludlow reservoirs. It became somewhat more serious after the new supply from the Little River was put in service. This water passes through a sand filter before being delivered to the city. At times the raw water is rather high colored and, in order to reduce this, alum is used at times in connection with the filter. The water is extremely soft. Alum was applied to the water in small quantities between April 30 and May 18, 1910, and soda ash was applied between May 6 and May 15. Between May 18 and July 15 no coagulants were applied. During this time, even when no chemicals were being used, the rusty water troubles became serious and a detailed study of the matter was made by the Chief Engineer of the Water-Works Department, Mr. Elbert E. Lochridge, and the writer.

It was found that the trouble was worst in certain apartment houses of recent construction, although a slight trouble was general throughout the city. The color of the hot water in the apartment houses varied all the way from 50 to 400, whereas the color of the cold water at the time ranged from 25 to 45. The hot water also contained large amounts of rusty sediment which, on analysis, was found to be composed almost entirely of oxide of iron. Iron was also present in solution or as a colloid. This caused red stains of iron rust on white porcelain basins and in many cases made the water practically useless for all domestic purposes. Many complaints were made to the water department and the matter was the subject of much ill-feeling between tenants, janitors and landlords. In some instances it resulted in the loss of tenants. It caused pipes to become choked and in one case is said to have resulted in the bursting of a boiler.

The boilers used were generally made of cast-iron, although in the case of one or two large installations steel boilers were found. The tanks were sometimes of galvanized-iron or steel, sometimes made of steel blacked on the outside and apparently with no protective coat on the inside. Their capacities varied from 100 to 500 gals. In practically every case where trouble was observed the water passed through one of these unprotected steel tanks.

The pipes used for the conveyance of the hot water were found to be chiefly of galvanized-steel. Possibly in some of the older installations they may have been galvanized-iron, but this could not be told from inspection. In one instance brass pipe was found in connection with a steel tank. In some of the private houses examined the hot water piping was of brass and lead and the boilers of copper. The quality of the galvanized pipe used differed considerably in different buildings. In some cases, especially the older installations, the pipe appeared to be of much better character than in the houses more recently built, the amount of zinc on the pipe being greater and the coating smoother. These pipes of better grade were almost invariably found in connection with galvanized tanks or with tanks covered with packing. The poorer qualities of galvanized pipe were usually found associated with the unprotected steel tanks, this being apparently a cheaper installation.

When it was found that the rusty water troubles were associated with the steel tanks and galvanized pipes of poor quality, an investigation was made to ascertain the character of the inside of some of the galvanized piping used in Springfield. Samples were obtained from various plumbers and dealers, from the stock of pipe in the water-works yard, and from pipes used in other cities. These samples were sawn asunder so as to expose the interior. The results, taken as a whole, showed extremely bad conditions. Scarcely a single specimen of a perfect pipe was obtained. In some cases there were large areas of the interior of the pipe entirely uncoated with zinc, and where the steel was exposed and coated with rust; others were spotted with pieces of mill scale embedded in the zinc coating; others were rough from the presence of dross from the spelter bath; sometimes a line was found along the seam where the coating had not adhered to the pipe, possibly on account of the failure of the acid to remove the mill scale during process of galvanizing. In several pipes where the coating was good, as far as the eye could see, microscopical and chemical tests showed the presence of pin holes where rusting might occur. In some instances a poor coating of zinc on the inside was accompanied by a poor appearance of the outside coating, but the samples as a whole showed that it was not always possible to tell the nature of the inside pipe from the appearance of the outside. A number of samples of galvanized-iron pipe obtained from different dealers and plumbers, from the water department stock and elsewhere, were carefully examined both on the outside and inside, the specimens being sawn in two for that purpose. The physical appearance of the coatings was first recorded, after which the specimens were examined with the microscope and tested for porosity by means of Walker's test and by the use of ferricyanide.

Walker's test was made as follows: The raw edges of the iron and bare spots were first coated with asphalt in order to protect them and then the specimens were placed in a solution of boiling caustic potash. If any iron remained exposed and in contact with the zinc, bubbles of hydrogen gas were generated and could be easily seen with the eye. In the case of many specimens this test was not necessary, as the bare, uncoated spots could be easily detected without it, but in other specimens, which to the eye appeared to be thoroughly coated, this test revealed the presence of pin holes. These might become foci of corrosion, and the beginning of tubercle formation. As corrosion proceeded such tiny bare spots would increase in size until finally a large area was exposed. No specimen was examined that did not show at least one or two such pin holes. The character of the coating on the outside did not always indicate the character of the coating on the inside; that is to say, a good exterior did not necessarily mean a good interior. A bad exterior, however, was invariably accompanied by a bad interior.

WATERS OVERDOSED WITH ALUM.—It sometimes happens with mechanical filter plants that more alum is used than can be decomposed by the alkalinity naturally present in the water. When this occurs the filtered water becomes acid and its corrosive powers are greatly increased. Such waters are liable to be the cause of the rusting of iron and steel pipes, tanks, etc., with both cold and hot water. Instances of this kind have not infrequently come to the attention of the writer.

MECHANICAL FILTRATION WITHOUT RED WATER TROUBLES.—In order to correct any misapprehension in regard to mechanical filtration, it should be stated that mechanical filters with alum used as a coagulant

have been in service for many years in many cities of this country, without being the cause of any red water plague. But where this is the case the waters are relatively hard and the filtered water has a considerable residual alkalinity. The writer has corresponded with many engineers and chemists in various cities where mechanical filters have been used, and the dividing line between those which have caused trouble and those which have not appears to be sharply drawn according to the hardness of the water; that is to say, the use of alum with hard water causes no trouble, whereas the use of alum with soft waters may cause serious trouble.

WATERS NATURALLY CHARGED WITH IRON.—Many public water-supplies contain excessive amounts of iron and with these rusty water is common, both cold and hot. At Far Rockaway, N. Y., Red Bank, N. J., Superior, Wis., Reading, Mass., and elsewhere, filter plants have been constructed for removing iron. Methods of deferrization have been well described by Weston (Trans. Am. Soc. C. E., Vol. 64, Sept., 1909).

SEASONAL OCCURRENCE.—It is difficult to state any particular time of the year when the red water troubles are at their maximum, but generally speaking, so far as the observation of the writer has gone, the fall and winter months are the worst.

LOCALIZATION OF RED WATER TROUBLES.—Wherever the red water plague has been observed a most conspicuous phenomenon has been that the rusty hot water has not been general throughout the city, but has differed greatly in different houses. Often many houses are practically exempt, while neighboring houses may be seriously affected. This was conspicuously true in one instance in Springfield, Mass., where there were two apartment houses on the same street taking water from the same mains under identically the same conditions and with the plumbing arranged in substantially the same way. In one of these apartment houses no trouble was experienced, while in the other the conditions were very bad. The only noticeable difference between these two buildings appeared to be in the character of the material used for the construction of the heaters, tanks and piping used for the hot water services.

If one were to generalize, it may be said that it has usually been found that houses recently built have suffered more severely than older houses; that houses in which brass pipe and copper boilers have been used have suffered little or none at all; that houses in which galvanized wrought-iron or steel pipe have been used have been the ones affected and those in which the piping has been apparently of poor quality have suffered the worst. The troubles have been somewhat more marked in buildings where the circulating pressure system is used than in those where the tank system is used, but exceptions have been found, as, for instance, in tall buildings. In short, the physical conditions that appear to favor the formation of iron rust in hot water are higher pressure, higher temperature, and greater circulation.

TEMPORARY RUSTINESS.—It is a matter of common occurrence to find the first water drawn from a hot water faucet to be somewhat rusty, the water afterwards running clear. This may happen even in places where there is no general red water problem. It is especially likely to happen when the water contains such electrolytes as sodium chloride. It is due to galvanic action between different metals. Thus, where brass faucets have been attached to steel pipes the writer has found the first tumblerful of water drawn to be rusty and the water afterwards drawn to be clear.

SOFT WATERS MORE CORROSIVE THAN HARD WATERS—[Experiments cited to show this.—Ed.] The fact that very soft waters are more corrosive than hard waters was illustrated by the following laboratory experiments. Four flasks containing distilled water, Brooklyn tap water, and mixtures of the two, were fitted with return condensers and boiled for six hours. Into them had been placed strips of Russia iron of equal size, but before they were introduced the water had been boiled to remove any carbonic acid. After boiling, the strips of iron were removed and the amount of iron dissolved in the water determined by analysis.

ROLE OF CARBONIC ACID.—Carbonic acid dissolved in water increases the hydrogen ions present and therefore increases its corrosive properties. This is a fact too well known to require proof. Carbonic acid is present to some extent in nearly all natural waters. In swampy waters it is high and in many well waters it is very high. The use of alum in water increases the carbonic acid and therefore tends to increase its corrosive properties. Carbonic acid is very soluable in water. It is driven off by heat, but not when under the pressure existing in city mains. Carbonic acid in hot water in the presence of the carbonates of the alkaline earths does not appear to have the corrosive properties that it has in soft waters.

ROLE OF ORGANIC ACIDS.—Very little is known chemically about the effect of organic acids in the corrosion of iron. It has been generally considered that swampy waters owe their corrosive properties in part to humic acid or similar organic substances. Such waters nearly always contain carbonic acid and some chemists have recently claimed that the corrosive properties are due to this carbonic acid rather than to the organic acids themselves (K. Endell, Jour. prakt. Chem. 82, 414-22). There is reason to believe, however, that the organic acids play a considerable part, especially in the case of fresh extracts.

DIFFERENCE BETWEEN FRESH AND OLD EXTRACTS OF ORGANIC COLORING MATTER.—In the course of various experiments on decolorization, marked differences have been found between fresh and old extracts of coloring matter. It is a well-known fact that the hue of colored waters varies at different seasons and that fresh extracts of leaves and recent vegetations have a greenish hue, while the older extracts of peat found in the swamps have a reddish hue. This appears to be due to oxidation of the iron present.

Analyses have shown that old and new extracts of the same color differ materially with respect to the amount of organic matter present. [The further discussion of this subject, with analytical tables, is omitted.—Ed.]

ACTION OF SULPHATE OF ALUMINA.—When sulphate of alumina is added to water that contains calcium carbonate, the following reaction takes place.

$$Al_2(SO_4)_3\ 18\ H_2O + 3\ Ca\ CO_3\ CO_2 + 3\ H_2\ O = 3\ Ca\ SO_4 + 2\ Al\ (OH)_3 + 6\ CO_2.$$

The products of the reaction are, aluminum hydrate, which is the coagulant desired, calcium sulplate, which remains in solution, and carbonic acid gas, which also remains in solution. When the amount of calcum carbonate present is relatively large, this reaction takes place quickly, but when the alkalinity is low the reaction appears to take place more slowly. This has been shown by various conductivity experiments made for the writer by Mr. Melville C. Whipple. This is in line with the well-known laws of mass action.

From the observations and experiments it seems reasonable to believe that with colored waters a double reaction takes place and that a small part of the alum unites with the organic matter directly, while the larger part reacts with the calcium carbonate in the manner above mentioned. The nature of this aluminum organic compound is not known. Possibly it exists as a colloid.

When the amount of calcium and magnesium carbonate naturally present in the water is insufficient to decompose the alum added, alkalinity may be provided by the use of sodium carbonate, lime or even sodium hydrate. The use of the latter is somewhat troublesome. Soda ash has some advantages, but experience has shown that at Watertown it did not prevent the rusty water conditions.

ALUM COMPOUNDS IN THE FILTERED WATER.—Under ideal conditions, all of the alum added to the water before filtration is decomposed and takes the form of aluminum hydrate, which is removed by the filter. Under some conditions, however, aluminum compounds may conceivably persist in the filtered water even though no alum, as such, remains. If the filter is not working propertly, some of the hydrate of alumina may pass through the sand. If present in large amounts this would produce a slight turbidity or opalescence in the water. If present in very small amounts it might give to the water merely a bluish cast. It is believed by some physicists that the natural blue color of large bodies of water is due to the presence of aluminum compounds.

If the alum reaction should not be complete, but if a small amount of basic sulphate should be formed, it is possible that this might remain as such dissolved in the filtered water. The alum commonly used for filtration purposes is "basic"; that is, it contains a larger amount of aluminum than that theoretically required to combine with the sulphuric acid. It is possible that a part, at least, of this excess is present in the form of basic sulphate, and not as aluminum hydrate.

EFFECT OF HEAT ON AN ALUM-TREATED WATER.—If the filtered water should contain basic aluminum sulphate it is reasonable to believe that heating it would tend to complete the reaction so that aluminum hydrate would be precipitated in the hot water. If the filtered water contained aluminum sulplate in combination with organic matter, heating might decompose it and this also would tend to throw down the aluminum hydrate in the hot water. In this connection it is worthy of note that in Watertown analyses of the deposits in the hot water pipes have shown considerable quantities of aluminum, sometimes as high as 7%.

These changes in the basic sulphates and combinations of alum with organic matter would naturally tend to increase the hydrogen ions and therefore the corrosive properties of the water.

Experiments have shown that when alum is so added to waters the alkalinity of the filtered water is reduced to 5 or 8 parts per million, the filtered water, after long boiling, has an acid reaction when tested with the phenolphthalein indicator, whereas the reaction is alkaline if the residual alkalinity of filtered water as shown by the ordinary methyl orange or erythrosene test is kept higher than 5 or 8 parts per million. Many experiments along this line have been made [and plotted] by the writer. From a smooth curve drawn through these results it would appear that when the alkalinity of the filtered water falls below six parts per million the water will commonly have an acid reaction with phenolphtalein after boiling. This acidity of the hot water is apparently not due to carbonic acid.

Whatever may be the explanation (and the chemistry of the subject is by no means clear) the fact appears to be well established that as a result of the application of sulphate of alumina to soft, colored waters, a corrosive property is imparted that acts when the water is heated, but that is insignificant as long as the water remains cold.

OXYGEN CONDITIONS.—The theory of corrosion and rusting requires not only the presence of the hydrogen ion, but the presence of oxygen. It has been well proved that where the hydrogen ion is present the rusting of iron is proportionate to the concentration of the oxygen. The greater the amount of oxygen, therefore, the greater the rusting. Generally speaking, hot water contains more than enough oxygen to oxidize the iron dissolved and it is probable that the increased corrosion attending increased amounts of dissolved oxygen is due to its action as a depolarizer.

Surface waters used for public supplies usually contain oxygen up to their saturation point. The solubility of oxygen decreases as the temperature rises. Near the freezing point water will hold in solution about twice as much oxygen as at summer temperatures. The solubility decreases according to a regular curve and at the boiling point becomes nil.

The solubility of oxygen is also affected by pressure and increases directly with it. Water under a pressure of two atmospheres will hold twice as much oxygen as water under a pressure of one atmosphere. When water saturated with oxygen is heated, the pressure remaining the same, oxygen gas is liberated. This is also true of the dissolved nitrogen. When a glass of cold water is allowed to stand in a warm room, bubbles of air may be seen collecting on the glass. In order for supersaturation to occur when water is under pressure it is necessary to raise the temperature considerably and the greater the pressure the higher must the temperature be raised. For example, water just above the freezing point contains 14.5 parts per million of dissolved oxygen. If placed under a pressure of 40 lbs. per sq. in., it would be necessary to raise the temperature to 135° F. in order for super-saturation to occur, and if the pressure were 100 lbs. per sq. in., it would be necessary to raise the temperature to 170°. When heated above the saturation point, a portion of the air will go out of solution. This occurs to some extent in domestic hot water systems. The rumbling of kitchen boilers is a common phenomenon in houses where the tank system is used and the pressure is low. The liberated air ultimately finds relief through the expansion pipe or the opened taps. It has been commonly noticed in feed water heaters that the corrosion increases with the temperature of the water up to a certain point, which is somewhere between 170° and 190° F., and above that decreases.

Galvanized iron or steel pipes are largely used in connection with the heating of houses by the hot water system. These pipes do not often corrode seriously, an obvious reason being that the water is used over and over and the oxygen becomes used up and its power of rusting brought to an end.

EFFECT OF CIRCULATION.—Experience has shown that the more rapid the circulation of water through a hot water system the greater is the rusting of the pipes. The circulation of the water prevents the accumulation of hydrogen on the metallic iron; that is, prevents polarization. This, together with the mechanical removal of the oxidized iron, tends to increase the corrosion. The growing tendency to use the circulating system may in part explain why the rust problem is more serious now than formerly. Allusion has already been made to the fact that the circulating pipes between the heaters and boilers often become completely choked with rust when the rest of the system is much less affected.

ACTION OF SOFTENED WATERS ON GALVANIZED PIPE.—It has been found at St. Louis, Columbus, and other cities where water has been softened by the use of lime, or where lime has been used in connection with copperas as a coagulant, that the treated water contains normal carbonates. It acts on the zinc coating of pipe, dissolves the zinc as a zinc carbonate and thus exposes the metallic iron to the water. It has been found even that such water will remove zinc from an alloy, and meters and other fixtures have suffered in consequence. Such waters do not naturally corrode iron; but if, after the service pipe has become thus exposed, there should be a change in the character of the water, so that there were no longer an excess of hydroxyl ions, the rusty water problems would probably become a serious matter.

IRON AND STEEL PIPE.—There seems to be abundant reason to believe that the character of the iron and steel pipe used has a most important influence on the rusty water problem. In Springfield the inspections of the apartment houses plainly indicated that the worst red water conditions existed in the buildings of cheaper construction, where unprotected steel tanks were used for storing the hot water and galvanized steel pipes were used for its distribution. Some of the piping that was examined was found to be deeply pitted and

the pipes completely choked with iron rust. Examination was made of some of these pipes. They were found, for the most part, to be made of steel and very badly galvanized. The pipes of better grade appeared to be less corroded. Woolson, in his study of the New York bathing houses, found that in the pipe lines wrought-iron and steel were indiscriminately used. Both were more or less corroded.

Laboratory experiments that have been made by various authorities have shown relatively little difference in the corrosion of wrought-iron and steel pipes. Where tests have been made by immersing samples in strongly acid solutions, steel pipes have sometimes given slightly better results than wrought-iron pipes, and sometimes not as good. The laboratory data on this point are inconclusive. On the other hand, it seems to be common experience, and it is certainly the prevailing idea among engineers that so far as corrosion by water is concerned, wrought-iron pipes stand better than steel pipes. Whether this is due to inherent differences between the two metals or to more frequent imperfections in the manufacture of steel is something that cannot be readily determined from the data at hand. Homogeneity is an important element in the prevention of corrosion and it is apparently possible for steel pipe to suffer more in this respect than pipe of wrought iron. So far as practical experience goes, it appears to be true that the best results are obtained by using the best grades of wrought iron; yet there is reason to believe that the better grades of steel pipe are more satisfactory than the poorer grades of wrought iron.

Much depends upon the thoroughness with which the galvanizing process is carried on. For the best protection pure zinc should be used, and not an alloy. It should be of sufficient thickness and applied so as to thoroughly cover the pipe at all points. The old-fashioned dipping process gives best results. Sometimes the galvanized coating is put on by a method of electroplating. This is not satisfactory, for various reasons. Usually the coating applied in this way is much too thin. Wiping a pipe after dipping also produces a thin coat. To obtain a galvanized coating of satisfoctary quality it is necessary to exercise great care in its manufacture. In the haste to turn out large quantities of pipe in a short time there is danger lest the process of galvanizing be slighted. If the mill scale is not properly cleaned from the pipe; if the acid used in pickling is not thoroughly washed off; if the acid used in tures of pipe and zinc are not right; if the zinc bath is used too long, so that dross accumulates in the dipping tank, and if other precautions are not taken, the galvanized coating will not be satisfactory.

At the present time plumbers have difficulty in obtaining galvanized pipe that can be recognized as satisfactory in quality. No one seems to know what requirements to specify and even if the specifications be properly drawn there is difficulty in making sure that the material furnished complies with them. Comparatively few plumbers are able to tell steel from iron. The threading test has been proved to be unreliable in the hands of many. A more practicable method is to saw off a short ring from the end of the pipe and break it with a sledge, the fracture being crystalline if steel, but fibrous if wrought-iron. Sometimes even this fails. The chemical tests are, of course, more conclusive, but are not available to the ordinary plumber or purchaser. It is not uncommon for a plumber to specify wrought-iron pipe and be furnished with steel pipe or with a mixture of both wrought-iron and steel.

Inspections of the galvanizing are seldom made with sufficient care. To inspect the interior of a pipe is difficult, but some idea of the smoothness of the coating may be obtained by throwing a ray of sunlight through the pipe with the aid of a mirror. Roughnesses and bare spots of large size can be thus detected. There seems to be no doubt that while it is possible to obtain good pipe in small sizes there is on the market at the present time a very large amount of steel pipe of inferior quality. There is also some poor wrought-iron pipe, but the amount of poor steel pipe is larger, doubtless because more steel pipe is made.

In the case of cast-iron pipe it is customary for manufacturers to so mark the pipe that it can be identified. This practice is not generally applied to wrought-iron or steel pipes of small sizes. Some wrought-iron pipe manufacturers brand all pipes larger than 1½ ins. in diameter, and one company brands its pipe down to ¾-in. sizes. It would be of material benefit to all concerned if the practice of branding pipes for identification should become universal. Mr. A. L. Webster, a well-known sanitary engineer of New York City, has recently investigated the question of the purchase of small-sized pipe and has found the trade conditions existing between manufacturers, agents, dealers and plumbers to be such that it is now practically impossible for a purchaser to know the quality of the pipe that he is paying for. He has rightly insisted, in the case of a large contract, that no pipe shall be furnished that cannot be identified and that cannot be proved to correspond in every respect to the specifications.

REMEDIES.—If the above-mentioned theories of corrosion are correct, the logical methods to be used for preventing rusty hot water would be along the lines of reducing the hydrogen ions in the water or increasing the hydroxyl ions, getting rid of the dissolved oxygen, reducing the pressure, temperature and circulation; and using pipes of good quality selected with reference to the nature of the water. Practice can follow theory to a certain extent.

There seems to be no doubt that the most effective method of avoiding rusty hot water is to use brass or some other metal other than iron or steel for the hot water pipes and boilers. This increases the expense of the installation but with very soft waters it is advisable. If brass is used it should be properly alloyed and well annealed; proper fittings also should be used.

If wrought-iron or steel pipes are used they should be of the best quality and should be well protected by a galvanized coating of pure zinc applied by the dipping method. Experience appears to indicate that wrought-iron pipes of the best grade resist corrosion better than steel pipes, but so many exceptions have been found to this that it cannot be considered as definitely established. Poor grades of both steel and iron pipes are to be avoided. A vigorous reform should be instituted in the manufacture and methods of branding and sale of smaller-sized pipe for use with hot water.

In domestic hot water supplies it is not feasible to prevent circulation of the water in the pipes; nor is this desirable, as the circulating system possesses a number of distinct advantages. The pressure of the hot water must depend chiefly upon practical physical conditions, but in designing a system where red water troubles are feared, low pressure should be favored. There seems to be no doubt that in many cases the temperature of the hot water supply is maintained higher than is necessary for domestic uses, and in such cases the red water plague could be materially alleviated if means were taken to prevent excessive heating.

Neither is it feasible nor desirable to remove the dissolved oxygen from a public water-supply, as has been recommended for the Coolgardie supply in Australia. It is some times done in the case of water used for boiler purposes and the results are said to be beneficial. There is no reason why it could not be done for hot water installations in large buildings, as in apartments, hotels and office buildings, where large numbers of taps are supplied from a common source. By first heating the water to a rather high degree, say 80° to 90° C., and then carrying it to an open tank at the top of its building, a large amount of the dissolved oxygen would be liberated and its corrosive power materially diminished. A more complete removal might be obtained by the used of a closed storage tank with a partial vacuum.

The most effective method of preventing rusty hot water, next to the avoidance of iron and steel pipe, is to reduce the hydrogen ions in the hot water to a minimum, or, what amounts to the same thing, to increase the relative number of hydroxyl ions. This practically amounts to saying that the public water-supply should not be too soft. Experience seems to indicate that the alkalinity should be at least 10 or 15 parts per million. The higher the alkalinity the less danger of rusty hot water. But it must be remembered that the hardness of water is in itself objectionable, and that when it is more than 15 or 25 parts per million it begins to have a noticeable effect on the use of soap.

Public water-supplies high in organic matter and low in alkalinity may be advantageously hardened by the addition of a small quantity of lime, say 10 or 15 parts per million. This practice has long been common in England.

The use of alum with soft, colored waters should be avoided as far as possible, but if it is employed lime (or soda) should be used with the alum in order to prevent the alkalinity from falling too low. But here again is a difficulty, for when deeply stained waters are decolorized with alum it is found that the additional use of lime and soda prevents to some extent the satisfactory decolorization of the water. In such cases considerable care must be used in adjusting the chemicals, and in the present state of the art it is not always possible to obtain entirely satisfactory results. The problem of color removal for soft waters has not yet been satisfactorily solved.

With hard waters, practically no precautions are necessary to be taken, as the hardness itself seems to be sufficient to prevent rusty water troubles.

Finally, it is evident that the problem of rusty hot water is a complicated one. Its solution demands the united efforts of water-works engineers, plumbers and pipe manufacturers. Economy to the householder demands that the quality of a public water-supply be considered not alone from the hygienic standpoint but from its possible influence on pipes and fixtures, and that on the other hand the materials used for distributing the water be chosen with reference to the inherent qualities of the naturally available supply. Plumbing regulations should be drawn with this in mind. But all these precautions will be of no avail if pipes of satisfactory quality cannot be obtained and recognized by the ordinary dealer and plumber. To this end two things are necessary, properly drawn specifications and a simple method of branding.

Cost Data on Bituminous and Waterbound Macadam Roads.

By W. G. HARGER.*

New methods of construction have so changed the cost of road improvements that engineers who are just going into this work, or are not familiar with the present methods, are often handicapped in making estimates.

The cost data given in this article has been gathered chiefly since 1907, and covers most of the items necessary for estimating the cost of an ordinary road job. Such data must be used intelligently or they will be misleading. Local conditions should always govern in making estimates. It is best to describe the conditions to which the given data refer and leave the special application to the one using the data.

Where machinery is used I have found it much more satisfactory to include the items of interest, depreciation and repairs in a lump sum item for the whole contract than to try to reduce them to a yardage basis. These charges will therefore be considered under the heading "Plant and Payroll."

Cost of Earth Excavation.

Table I. shows the cost of earthwork on four roads in New York State, which represent easy, average, and difficult work. The cost per cu. yd. includes excavation and placing in fill, shaping the subgrade for the stone and trimming the shoulders and ditches. For heavy fills with short hauls wheeled scrapers were used, but the largest part of the work was done by wagons.

Cost of Rock Excavation.

I have no reliable personal data on ledge rock excavation. Rockwork on roads is usually a small item; the cuts are small and consequently expensive. Perhaps there is no item more variable in cost than small rock cutting. It is therefore safer to take as a basis of estimate the bids of experienced road contractors. The reports of the Massachusetts Highway Commission and bids on New York State work show that prices for rock excavation range from $1.50 to $2 per cu. yd. for quantities up to 200 or 300 cu. yds., and $1.25 to $1.50 for larger quantities.

Cost of Unloading Broken Stone.

For making estimates of the quantity of stone required the following data on imported stone used on Road 5021 will be useful. The approximate sizes and actual weights of stone on this work were as follows:

No. 1 Screenings, ½-in. screen.....2,550 lbs. per cu. yd.
No. 1A Dustless screenings, ½-in. screen with dust jacket.....2,350 lbs. per cu. yd.
No. 2, 1-in. screen.....2,470 lbs. per cu. yd.
No. 3, 2-in. screen.....2,350 lbs. per cu. yd.
No. 4, 3½-in. screen.....2,420 lbs. per cu. yd.

For purposes of estimating the cost of handling imported crushed stone, the following weights for a cubic yard, based on railroad weights will be used, No. 1, 2,600 lbs.; No. 1A, 2,400 lbs.; No. 2, 2,500 lbs.; No. 3, 2,400 lbs.; No. 4, 2,400 lbs.

UNLOADING CARS BY HAND.—On Road 5021, with the author as engineer, a number of short time (10-hr.) estimates made the cost of unloading per ton $0.12 to $0.135; and the cost per cu. yd. $0.14 to $0.16. This work was in 1910, and labor cost $0.175 per hour. The shovelling was done from a steel platform, where it was dumped from hopper-bottom cars. When shovelled from inside the cars the cost may run as high as $0.20 per cu. yd. The cost of shovelling is usually estimated at $0.15 per cu. yd.

UNLOADING CARS WITH ELEVATOR PLANT.—Where there is a large quantity of stone to be unloaded, it often pays to put in a switch. Six-car switches can usually be put in for about $300. Where there are competing railroads no charge is usually made.

The following data are from Road 5046, season of 1910, with labor at $0.17 per hour. A total of 3,470 tons or 2,900 cu. yds. was unloaded at $0.08 per ton, or $0.095 per cu. yd. The cost was divided as follows:

*Asst. Engineer, N. Y. State Highways, 16 Hinsdale St., Rochester, N. Y.

TABLE I.—EARTH EXCAVATION.

Road No.	Length, miles.	Total excavation.	Wages per hr. Men.	Wages per hr. Teams.	Cost per cu. yd.	Kind of Soil.	Engineer.
1*	2.5	8,600	$0.175	$0.45	$0.452	Loam and gravel, easy work.	E. E. Kidder.
2	5.5	28,000	0.175	0.45	0.484	Largely clay, hard excavation.	S. O. Steere.
3	6.0	18,000	0.15	0.45	0.46	Gravel, sand, clay, loam, etc., av. work.	W. G. Harger.
4*	4.0	10,000	0.175	0.40	0.65	25% of excavation, small boulders, unusually hard excavation.	W. G. Harger.

*The cost of trimming the shoulders on Road No. 1 was $345 per mile; on Road No. 4, $700 per mile.

Setting up elevator at Scottsville	$60.00
Setting up elevator at Munford	40.00
Labor of operation	154.00
Gasoline and oil	20.00
Total	$274.00

This method of unloading is not only cheaper than hand methods, but also cheapens the cost of hauling, as no time is lost in loading the wagons. There is also saving in car demurrage if the bin be made large enough for two or three car loads.

UNLOADING CARS FROM COAL TRESTLE.—This data is taken from the Scottsville Road repair work; Mr. Harold Spelman, Engr., season of 1910; labor at $0.20 per hr.; average force two or three men. A total of 4,400 tons was unloaded. The cost was divided as follows:

Rent of trestle	$125.00
Labor	232.00
Total	$357.00
Cost per ton	$0.081
Cost per cu. yd.	$0.008

UNLOADING FROM CANAL BOATS.—The plant used consisted of a portable bin and a horse operated derrick; Road 5014; Mr. James Anderson, contractor. The average amount of stone unloaded per day was 150 tons. The cost was $0.115 per ton, or $0.14 per cu. yd., divided as follows:

1 Team and driver	$4.00 (10-hr. day)
1 Foreman	2.50 (10-hr. day)
6 Laborers, at $1.75	10.50 (10-hr. day)
Total	$17.00

Cost of Hauling Broken Stone.

Table II. shows the cost of hauling stone on good roads as for repair work. The wagons were loaded from bins, so no time was lost in loading.

TABLE II.—HAUL OF STONE ON GOOD ROADS FOR REPAIR WORK.

Road No.	Engineer in charge.	Price per hr. of teams.	Length of haul, miles.	Cost per ton mile.	Cost per yd. mile.
1	Harold Spelman	0.50	1.8	$0.20	$0.24
1	Harold Spelman	0.50	1.2	0.24	0.288
2	G. G. Miller	0.62	2.0	0.20	0.24
2	G. G. Miller	0.62	1.7	0.215	0.26
2	G. G. Miller	0.62	1.1	0.23	0.275
2	G. G. Miller	0.62	0.6	0.25	0.30
2	G. G. Miller	0.62	0.2	0.50	0.60
3	G. G. Miller	0.62	3.0	0.17	0.205
3	G. G. Miller	0.62	2.75	0.175	0.21
3	G. G. Miller	0.62	2.5	0.175	0.21
3	G. G. Miller	0.62	2.0	0.19	0.23
3	G. G. Miller	0.62	1.75	0.215	0.26
3	G. G. Miller	0.62	1.5	0.23	0.28

Road No. 1, 10-hr. day.
Road Nos. 2 and 3, 8-hr. day.
NOTE.—Cost per ton mile on Roads Nos. 2 and 3 equals the cost per yd. mile. for teams at $0.50 per hour.

For hauling on bad roads for new construction I have the following personal data:

CLOVER ST. ROAD, SECTION 1; season 1908; teams at $0.45 per hour; dump wagons loaded from bins; no time lost.
6,000 cu. yds., 0.6-mile haul, cost $0.26 per ton or $0.31 per yd.-mile.
4,500 cu. yds., 0.6-mile haul, cost $0.24 per ton or $0.29 per yd.-mile.

SCOTTSVILLE-MUMFORD ROAD; season 1911; teams at $0.45 per hour.
300 cu. yds., 1-mile haul (including a 5% sandy hill 1,200 ft. long), cost $0.30 per yd.-mile.
500 cu. yds., 0.5-mile haul (level road in bad condition), cost $0.30 per yd.-mile.

HAULING FIELD STONE AND FILLER.—This material was hauled from fields and pits where it was loaded by hand, and considerable time thus lost.

On the Clover St. Road, Section 1, season of 1908, with the author as engineer, and teams at $0.45 per hour, 10,000 cu. yds. of field stone were hauled an average of one mile for $0.36 per yd.-mile.

On the Scottsville-Mumford Road, season of 1911, with the author as engineer, and teams at $0.45 per hour, 500 cu. yds. of field stone were hauled 0.2 mile for $0.14 per cu. yd., or $0.70 per yd.-mile. On the same work 200 cu. yds. of filler was hauled 0.2 mile for $0.15 per cu. yd., or $0.75 per yd.-mile.

For all short hauls under ¼ mile the cost is high and practically the same on account of the larger percentage of time lost in loading.

MECHANICAL HAULING.—This method has not come sufficiently into general use to be considered in estimating, in the writer's opinion, unless teams are difficult to get. It rarely pays to use traction engines for less than a 3-mile haul, even on a hard road. In case they are used a light engine or road-roller and a train of ordinary dump wagons are more satisfactory than a heavy engine and large 5 or 7-cu. yd. cars. For maintenance and repair work, however, some style of automobile truck will doubtless be used in the near future.

Cost of Spreading Stone and Binder.

Table III. gives the cost of spreading broken stone on several New York State roads.

The ratio of the loose to the rolled depths varies with the size of the fragments and the depth of the course. Table IV. gives the averages of results obtained from 1,000 test holes made by the author on three separate roads. The last column of the table also gives the weights of No. 3 and No. 4 stone required to make a cu. yd. of rolled macadam. The amount of filler or binder per cu. yd. of rolled macadam is given in Table V.

TABLE III.—SPREADING STONE.

Reference No	Engineer.	Labor wage.	Depth of loose spread.	Amount spread.	Cost per ton.	Cost per cu. yd.
1	Harold Spelman	$0.20	4 ins.	7,000 tons	$0.066	$0.08
2	W. G. Harger	0.175	5½ ins.	6,000 cu. yds.	0.05	0.06
2	W. G. Harger	0.175	4 ins.	4,500 cu. yds.	0.07	0.083
3	W. G. Harger	0.20	6 ins.	1,000 cu. yds.	.....	0.05
		Placing sub-base stone.				
3	W. G. Harger	0.175	7 ins.	100 cu. yds	.....	0.10

TABLE IV.—RATIO OF LOOSE TO ROLLED DEPTH.

Size of stone.	Rolled depth.	Loose depth.	Ratio.	Weight per cu. yd. rolled measure.*
No. 4	4 ins.	5.2 ins.	1.3	3,120 lbs.
No. 4	3 ins.	3.8 ins.	1.27	3,050 lbs.
No. 3	3 ins.	3.9 ins.	1.3	3,120 lbs.
No. 3	2 ins.	2.4 ins.	1.2	2,880 lbs.

*Weight of 1 cu. yd. loose, 2,400 lbs., as noted at the beginning of the article.

The excessive amount of filler required for the 2-in. bituminous macadam (Table V.) was due to a layer of screenings placed under the No. 3 stone, all of which did not act as a filler. The small amount required for the 3-in. bituminous macadam was due to the fact that the bituminous binder partially filled the voids before the screenings were applied.

The ratio of loose to rolled depth for boulder sub-base is variable. If the size of boulders is practically the same as the depth of the course, that is if there is only one layer of stone, the loose depth and the rolled depth will be the same. Where there are two or three layers of boulders the ratio is approximately 1:1.25, i. e., a 12-in. rolled depth would require 15 ins. loose depth for boulders averaging 5 to 6 ins. in diameter.

COST OF LOADING FILLER AT PIT.—On the Clover St. Road, Section 1, during the season of 1908, with the author as engineer in charge, and labor at $0.15 per hour, 400 cu. yds. of sand filler were loaded at a cost of $0.12 per cu. yd. On the Scottsville-Mumford Road, with labor at $0.175 per hour, 200 cu. yds. were loaded at a cost of $0.13 per cu. yd.

COST OF SPREADING FILLER BY HAND FROM PILES.—On the Clover St. Road, Section 1, during the season of 1908, with labor at $0.15 per hour, 400 cu. yds. of sand filler were spread at a cost of $0.10 per cu. yd. On the Scottsville-Mumford Road, with labor at $0.175 per hour, the cost of spreading 200 cu. yds. was $0.20 per cu. yd. This included some hand brooming, but most of the brooming was done by a broom attachment on the roller.

COST OF SPREADING AND BROOMING NO. 1A AND NO. 2 STONE FOR BITUMINOUS MACADAM TOP COURSES.—A layer of No. 1A, ½-in. deep, was spread over the bottom course. On this was spread 2½ ins. of No. 3 stone. After rolling, bitumen was poured over this course and a ¾-in. layer of No. 2 stone spread and rolled; the excess of No. 2 was broomed off and a ⅜-in. wearing coat of No. 1A placed. The cost of spreading for a 2-in. top was as follows:

Cost per cu. yd. of No. 1A and No. 2	$0.282
Cost per ton of No. 1A and No. 2	.210

Eight hundred tons of this material was handled with labor costing $0.175 per hour.

For a 3-in. top course the procedure was the same, omitting the layer of No. 1A under the No. 3 stone. The cost of handling 400 tons for a 3-in. course was as follows:

Cost per cu. yd. of No. 1A and No. 2	$0.31
Cost per ton of No. 1A and No. 2	0.26

COST OF SPREADING SCREENINGS WITH CROSS DUMP WAGONS.—Wet dust screenings for waterbound macadam cannot be successfully spread in this manner. For spreading dry dust screenings, No. 2 stone or dustless screenings for bituminous macadam this method has proved the cheapest and most satisfactory. On Road 5046, season of 1910, a number of short time estimates made the cost of spreading by this method about $0.06 per cu. yd. The cost of brooming is slightly increased over that required by the hand spreading method, but not enough to counteract the advantage in the use of wagon spreading. On the Clover St. Road, season of 1908, 1,000 cu. yds. of screenings were thus spread for about $0.07 per cu. yd.

TABLE V.—AMOUNT OF FILLER AND BINDER REQUIRED.

Kind of course.	Kind of filler.	Amount of filler per cu. yd. of rolled macadam.	Weight of screening per cu. yd. of rolled macadam.
Bottom stone	Sand	0.35 cu. yds.	.....
Waterbound top	No. 1	0.5 cu. yds.	1,300 lbs.
3-in. Bit. mac. top	Nos. 1 A & 2	0.37 cu. yds.	900 lbs.
2-in. Bit. mac. top*	No. 1 A	0.6 cu. yds.	1,440 lbs.
Sub-base	Gravel	0.33 cu. yds.	.....

*Weight of cu. yd. loose, 2,400 lbs.

Cost of Rolling.

In the following costs lubricating oil is not included, as no reliable data was obtained as to the amount used. Gillette's "Handbook of Cost Data" gives this item as $0.30 per day; using this amount would increase the costs given below by from 0.2 to 0.3 of a cent per cu. yd. The amount of coal used was variously estimated at from 450 to 500 lbs. per day. As mentioned before, items of interest, depreciation and repairs of plant and equipment are not included in the cost per cu. yd. of stone consolidated.

On Road 5025, under Mr. E. E. Kidder, Engineer, during the season of 1910, the cost of rolling 3,400 cu. yds. of bottom stone and 1,700 cu. yds. of top stone, loose measure, was as follows:

Rollerman, 4 months, at $90	$360.00
Coal, ¼-ton per day, at $2.70 per ton, 80 days	55.00
	$415.00

The time and cost were divided as follows:

1/6 on sub-grade	$69.00
1/3 on bottom stone 4 ins. deep	138.00
1/2 on bituminous top stone 2 ins. deep	208.00

There was no cost for water. The roller worked 80 days in 4 months.

The cost of rolling per cu. yd. of loose material was: bottom stone, $0.04, and top (bituminous macadam), $0.12.

On Road 492, Mr. E. E. Kidder, Engineer, season of 1910, the cost of rolling a 4-in. bottom course was $0.03 per cu. yd., and for 3,200 cu. yds. of waterbound top stone $0.05 per cu. yd. Both quantities refer to loose measure. The roller worked 74 days in three months. The puddling was done by a pipe line and hose and brooms attached to the roller. The rollerman's wages were $90 per month and coal $2.75 per ton.

On Road 5021 the cost of rolling a 3-in. bituminous top course per cu. yd. of loose material was $0.09; for a 2-in. top, $0.11.

On Road 5046 a roller working 111 days consolidated 1,850 cu. yds. of field stone sub-base, 4,300 cu. yds. of bottom stone and 2,150 cu. yds. of top stone, loose measure. The depth of the sub-base was 6 ins. (rolled measure) the bottom course 4 ins. and the top course 2½ ins., bituminous macadam. The rollerman's wages were $90 per month and coal cost $2.75 per ton for ¼-ton per day. There was no cost for water. The costs were divided as follows: sub-base, $0.035; bottom stone, $0.045; top stone, $0.105 per cu. yd., loose measure.

Cost of Crushing Stone.

As a basis for all cost estimates for crushing, it is necessary to know something of the percentage of the different sizes of the crusher output. Table VI. gives the results of tests made by Mr. Archer White during the season of 1910 on ordinary limestone and sandstone boulders composing the average field stone. The crusher used was the largest Acme portable crusher. The tailings were recrushed and the stone divided into four grades: No. 1, ¾-in. screen; No. 2, 1½-in.; No. 3, 2½-in., and No. 4, 3½-in. From this data it may be seen that 1 cu. yd. of field stone makes 1 cu. yd. of crushed stone, and that it takes approximately 1.8 cu. yds. of field stone to make 1 cu. yd. rolled measure of sizes Nos. 3 and 4.

TABLE VI.—SIZES AND PROPORTIONS OF CRUSHER RUN.

Reference No.	Cu. yds. field stone delivered to crusher.	Cu. yds. crushed stone produced.	No. 1. Cu. yds. produced.	No. 1. % of total output.	No. 2. Cu. yds. produced.	No. 2. % of total output.	No. 3. Cu. yds. produced.	No. 3. % of total output.	No. 4. Cu. yds. produced.	No. 4. % of total output.	Kind of material.
1	195	190	36	19	18	9	64	34	72	38	Sandstone & limestone
2	187	182	32	17½	10	5½	70	38½	70	38½	Limestone
3	196	202	36	18	14	7	76	38	76	37	Limestone & sandstone
4	190	216	40	18	18	8	79	37	79	37	Sandstone
5	173	172	32	19	28	16	62	36	50	29	Poor sandstone
6	189	184	36	19½	16	9	*	..	132	71½	Limestone
7	165	170	32	19	22	13	*	..	116	68	Limestone
8	...	...	30	16	24	13	*	..	60	63	Soft sandstone

*No. 3 and No. 4 size mixed and placed on grade.

The cost of labor was $0.20 per hour. The engineman of the crusher plant received $0.25 per hour and the foreman $0.30 per hour. The field stone were loaded from a pile near the crusher into small dump cars running on a movable track. The loaded cars were drawn to the crusher by a small hoisting engine. The cost of bringing the field stone to the crusher pile is not included. The force loading consisted of 1 foreman, 11 laborers and 1 engineman. The force crushing consisted of 1 foreman, 4 laborers and 1 engineman. In 8 days 1,500 cu. yds. were crushed. The cost of the entire output per cu. yd. of loose measure was divided as follows:

Loading for crusher	$0.133
Hauling to crusher	0.013
Feeding to crusher	0.061
Engineer of crusher	0.013
Fuel and oil	0.030
Loading crushed stone from bins	0.010
Total	$0.260

CRUSHING GRANITE HARDHEADS AND SANDSTONE.—The following data is from the records of the Clover St. Road, Section 1, season of 1908. Labor cost $0.15 per hour and the engineman received $3 per day. The crusher used was a 10 × 20-in. Climax. A total of 5,000 cu. yds. were crushed at a cost per cu. yd. loose measure of $0.19; 7,000 cu. yds. of sandstone boulders were crushed at a cost of $0.103 per cu. yd. loose measure. These figures are for the total output of the crusher and include the costs of feeding to the crusher, the pay of the engineman, coal and oil, but do not include delivery to the crusher. On the Scottsville-Mumford Road under similar conditions the cost varied from $0.13 for granite and sandstone to $0.19 for granite hardheads, per cu. yd. of loose measure.

The following data is taken from the Report of the Massachusetts Highway Commission and refers to work done in Newtown, Mass. The crushed stone was divided into the following sizes.

Tailings	205 cu. yds.	17.5%
2½-in. stone	692 cu. yds.	57%
Screenings and 1-in.	300 cu. yds.	25.5%
Total	1,177 cu. yds.	100%

The material was cobble stones and labor probably cost $0.20 per hour, teams, $0.45. The cost per cu. yd. at the crusher was $0.445, or $0.33 per ton.

The cost per cu. yd. was divided as follows:

Teaming to crusher	$0.314	70.6%
Feeding to crusher	0.033	7.4%
Engineer of crusher	0.029	6.5%
Repairs, coal, oil, etc.	0.045	10.1%
Watchman	0.024	5.4%
Total	$0.445	100%

MATERIAL—Conglomerate.

Amount broken		1,288 cu. yds.	
Amount broken per hr.		8.9 cu. yds.	
Divided as follows:			Weight per cu. yd., loose.
Tailings	378 cu. yds.	29.3%	2,549 lbs.
2½-in. stone	668 cu. yds.	51.9%	2,368 lbs.
Screenings and 1-in.	242 cu. yds.	18.8%	2,727 lbs.
Cost per cu. yd. in bins at crusher			$1.112
Cost per ton in bins at crusher			0.885

Divided as follows:

Powder and repairs	$0.018	1.6%
Labor drilling	.249	22.3
Sharpening drills and tools	.023	2.1
Breaking stone for crusher	.420	37.8
Loading stone for crusher	.127	11.4
Hauling stone for crusher	.062	5.6
Feeding crusher	.053	4.7
Engineer for crusher	.038	3.5
Coal, oil, waste	.050	4.5
Moving and setting up crusher	.023	2.1
Watchman	.049	4.4
Total	$1.112	100%

MATERIAL—Greenish trap.

Amount broken	3,155 cu. yds.
Amount broken per hr.	7.7 cu. yds.

Divided as follows:

			Weight per cu. yd., loose.
Tailings	1,004 cu. yds.	31.8%	2,457 lbs.
2½-in. stone	1,618 cu. yds.	51.3%	2,383 lbs.
1-in. stone	323 cu. yds.	10.2%	2,277 lbs.
Screenings	210 cu. yds.	6.7%	2,585 lbs.
Cost per cu. yd. in bins at crusher			$0.898
Cost per ton in bins at crusher			0.745

Divided as follows:

	Cost.	Per cent.
Labor, steam, drilling	$0.092	10.3
Coal, oil, waste, powder, etc.	0.084	9.4
Sharpening drills and tools	0.069	7.7
Breaking stone for crusher	0.279	31.0
Loading stone for crusher	0.098	11.0
Hauling stone for crusher	0.072	8.0
Feeding crusher	0.053	5.9
Engineer of crusher	0.031	3.4
Coal, oil, waste and repairs of crusher	0.079	8.8
Other repairs	0.041	4.5
Total	$0.898	100

W. E. McClintock, Engineer, Chelsea, Mass., Season 1887.

Labor	$0.20 per hr.
Teams	0.45 per hr.

MATERIAL—Trap Rock.

Amount broken	1,718 tons
Stone delivered at crusher by sub-contractor for $0.75 per ton.	

COST.

Tools	$0.013
Oil, waste, etc.	0.016
Fuel	0.05
Stone at crusher	0.750
Crushing (labor)	0.194
Total, per ton	$1.023

Cost of Stone Fill Bottom Course.

The following data is taken from Road 5021, season of 1910; labor cost $0.175 per hour, teams $0.40 per hour.

The amount placed was 10,000 cu. yds., rolled measure. The average rolled depth was 1.1 ft. The surface was carefully brought to line and grade, allowing a variation of 1 in. either above or below, which inequality was taken out with the top stone. A 3-in. bituminous top course was placed directly on this fill. The top layer of bottom stone was sledged to reduce all stones to 8 ins. or under. Flint stone was used to fill the top 6 ins. and to surface the rough fill. The bottom course was of fence stone, hauled on an average about ½-mile. I estimate that 1 cu. yd. rolled measure required 1.25 cu. yds. loose. The cost of the bottom course per cu. yd. rolled measured was $1.03, divided as follows:

Loading, 1.25 cu. yds.	0.19
Hauling, 1.25 cu. yds. ½-mile	0.20
Placing, 1.25 cu. yds. and rolling	0.24
Sledging	0.15
Flint	0.10
Cost of fence stone	0.15
Total, per cu. yd.	$1.03

Cost of Applying Bituminous Binder.

The following data is taken from Road 5021, season of 1910:

LABOR.

Kettleman	$0.20 per hr.
Spreaders	0.20 per hr.
Plain labor	0.175 per hr.
Teams	0.45 per hr.

APPARATUS.

1—4-bbl kettle (coal burner) } Bitumen heated
1—2-bbl. kettle (wood burner) } to 400° F.
1—12-ton Kelly roller.
Spreading pots having a vertical slot ⅛-in. wide.

ORGANIZATION.

Rollerman acted as foreman.
1 Spreader.
1 Kettleman.
3 Laborers.
Average speed, 350 ft. of 16-ft. road per day.

QUANTITIES.

16,850 gals. laid in one coat covered 13,330 sq. yds. or 1.26 gals. per sq. yd.

COST, PER GAL.

Unloading and hauling ½-mile	$0.0015
Heating	0.0032
Spreading	0.0032
Rolling and supervision	0.0051
Total	$0.0130
Bituminous material f. o. b. Caledonia	0.095
Total, per gal.	$0.108

SECOND QUANTITY.

42,000 gals. covered 24,000 sq. yds. in one coat, an average of 1.75 gals. per sq. yd.

COST PER GAL.

Hauling 1¾ miles	$0.0032
Heating	0.004
Spreading	0.0039
Rolling and supervision	0.0042
	$0.0153
Bituminous material f. o. b. Caledonia	0.095
Total, per gal.	$0.1103

KENTUCKY ROCK ASPHALT.—I have the following data from the Clarence Center Road. Mr. John D. Rust, Engineer, collected during the season of 1910. In this work an 8-ton tandem roller was found to do better than a 6-ton tandem. The cost of handling, spreading and rolling this material, from data of five selected days, varied from $0.033 to $0.036 per sq. yd.; the average being $0.034. The following may be taken as a typical analysis of this cost:

Abbreviations:
L = Laborers.
F = Foreman.
T = Teams.
E = Roller engineer.
Asphalt, $10.25 per ton f. o. b. unloading point.

RUN OF JULY 20TH, 1909.

69.22 tons hauled and placed.
1,730 sq. yds. covered.
80 lbs. asphalt per sq. yd.

5	L. at cars, 10 hrs., at $1.50	$7.50
½	F. at cars, at $2.25	1.12
5	T. haul, 2 miles, at $4	20.00
1	T. at shredding machine	4.40
5	L. on wheel barrows, 11 hrs.	8.25
3	L. on rakes, 11 hrs., at 15 cts.	4.95
3	L. shovelling, 11 hrs., at 15 cts.	4.95
1	F. at shredder, 11 hrs, at 22.5 cts.	2.48
1	E. on roller, 11 hrs., at 30 cts.	3.30
Total		$56.95

Cost per sq. yd., $0.033.

TABLE VII.—MATERIALS REQUIRED FOR 1 CU. YD. OF CONCRETE.

Mixture.	Cement.	Sand.	Stone.
1-2-4	1.5 bbls.	0.4 cu. yds.	0.9 cu. yds.
1-2½-5	1.2 bbls.	0.45 cu. yds.	0.92 cu. yds.
1-3-6	1.0 bbl.	0.45 cu. yds.	0.95 cu. yds.

Cost of Concrete Work.

The following data will help in estimating the cost of small concrete jobs such as culverts, walls, etc. This data was collected by Mr. E. E. Kidder during the season of 1908. Table VII. contains the theoretical proportions of cement, sand and stone required for the three ordinary mixtures of concrete. These values were found by experience to agree with actual proportions very closely for ½-in. to 1¼-in. stone:

Forms (labor)	$0.58	per cu. yd.
Lumber	0.50	" " "
*Labor mixing and placing	1.18	" " "
*Foreman	0.20	" " "
*Broken stone at crusher	0.90	" " "
*Haul stone 1 mile	0.30	" " "
Sand at pit, at 65 cts. per cu. yd.	0.32	" " "
Haul sand 6 miles	0.75	" " "
*Taking down forms	0.10	" " "
Cement at culvert	2.00	" " "
Total	$6.83	" " "

*Items accurate. Other items approximately correct.
Labor, 15 cts. per hour.
Concrete hand mixed.
200 cu. yds. placed in small culverts, averaging 12 to 15 cu. yds. apiece.
Note.—The labor of placing the concrete is customarily sublet to masons for $2 per cu. yd.

Plant and Payroll.

Table VIII. shows in a convenient form the value of plants and largest weekly force account of two months' duration on 14 roads in New York State. From this and other information I should judge that a contractor has tied up, outside of money on plant and materials, from $5,000 to $8,000 for the full length of time the work is in progress; and that for short periods he may have as high as $15,000 to $20,000 invested.

TABLE VIII.—SPEED OF WORK, VALUE OF PLANT, FORCE ACCOUNT. SUMMARY OF PLANTS AND FORCE ACCOUNTS.

Road No.	Style of road.	Local or imported stone.	Kind of hauling.	Weekly force account.	Value of plant.	Speed of work.
1	16-ft. Bit. Mac.	Imported	Mechanical and teams	$1,000	$13,500	0.7 mi. per mo.
2	16 " " "	"	Mechanical	800	13,600	0.7 " " "
3	16 " " "	"	Teams	900	8,000	0.5 " " "
4	16 " " "	"	"	1,000	8,000	0.6 " " "
5	16 " " "	"	"	.....	4,500	0.4 " " "
6	16 " " "	" top (Local bot.)	"	1,900	14,500	1.3 " " "
7	16 " " "	Local	Teams and Mechanical	600	12,000	0.5 " " "
8	16 " " "	"	Teams	1,000	9,000	0.5 " " "
9	16 " " "	"	"	600	9,000	0.6 " " "
10	16 " Water "	"	"	1,600	10,000	1.2 " " "
11	16 " " "	"	"	1,000	10,500	0.8 " " "
12	16 " " "	Imported	"	1,000	6,000	0.7 " " "
13	14 " " "	"	"	1,200	12,600	0.7 " " "
14	16 " Resurfacing	"	"	500	5,000	1.5 " " "

Labor, $0.16 to $0.20 per hour. Average, $0.175.
Teams, $0.40 to $0.50 per hour. Average, $0.45.

INTEREST, DEPRECIATION, REPAIRS, ETC.—The following estimates show, in my judgment, about the amount of money required on the different styles of construction noted. These data are based on an outfit which would be capable of a speed of about 0.7 mile per month, or 5 miles in a season.

ADOPTED VALUE OF PLANT ITEMS.

Item.	Value.	Life.	Annual repairs.
10-ton roller	2,700	20 yrs.	$70
Brick roller	1,800	20 "	40
Traction engine	1,200	8 "	100
Crusher	900	8 "	400
Elevator	200		
Bin and screen	300		
5 HP. gasoline engine	250	8 "	50
Gas engine and pump	200	5 "	50
6,000 ft. pipe	600	say 10 "	10
Wagons	115	6 "	10
Hand tools	150	1 "	..
Plows	100	3 "	..
Road machine	200	5 "	10
Tar kettle	125-200	..	*10
Wheel scraper	70	5 "	10
Slush scraper	6	5 "	..
10-ton roller used for hauling	2,700	10 "	200
Hauling traction engine	2,200	8 "	200

*Including new tank every 3 years.

6% INTEREST AND DEPRECIATION ON PLANT ITEMS.

Item.	Interest.	Depreciation.
Roller	$162	$135
Traction engine	72	150
Crusher	54	100
Elevator	12	30
Screen	3	50
Bin	30	40
Gasoline engine	15	30
Gasoline pump	12	40
6,000 ft. 1½-in. pipe	36	60
Wagons	6	20
Hand tools	9	150
Plows	6	30
Tar kettle	12	10
Concrete mixer	120	..
Brick roller	108	100
Wheel scrapers	5	15
Slush scrapers	..	..
Roller used for hauling	162	270
Hauling engine	132	900

Charge for bond ¼% total contract.

PLANT FOR WATERBOUND MACADAM IMPORTED STONE.

Elevator unloading plant, provided more than 2,000 cu. yds. stone is to be unloaded.

Item.	Interest.	Depreciation.	Repairs.
Elevator	$12	$30	$50
Bin	30	40	50
5-HP. gasoline engine	15	30	50
1 roller with broom and sprinkler attachment	162	135	70
6,000 ft. 1½-in. pipe	36	60	10
Gasoline engine and pump	12	40	50
Hand tools	9	150	..
Plows	6	30	..
Road machine	12	40	10
2 wheel scrapers	5	15	10
2 slush scrapers	..	..	..
15 wagons	80	300	150
Totals for 1 season's work 5 miles	$379	$870	$450
Total per mile	$76	$174	$90

Force account money out:
Allow 6 weeks out continually for length of job at ½% interest per month.
Allow $6,000 out, or $40 interest per mile on force account.
Bond charge:
¼ of 1% contract price; approximately $25 per mile.
Insurance charge:
$2. per $100 total force account; Approximately $100 per mile.
Allow for moving plant on job, $500, lump sum.

PLANT FOR WATERBOUND MACADAM LOCAL STONE.

Item.	Interest.	Depreciation.	Repairs.
1 traction engine	$72	$150	$100
1 crusher and bin	100	220	400

Roller, Pipe, Gasoline engine and pump, Hand tools, Plows, Road machine, Scrapers and Wagons as for imported stone plant.

1 steam drill and bits	10	50	80
1 small boiler for drill	12	30	20
Total for season, 5 miles	$521	$1,235	$910
Total per mile	$104	$247	$182

Force account slightly larger on local stone roads.
Approximately $7,000 out.
Interest on force account ..... $50 per mi.
Bond charge ..... 20 per mi.
Insurance ..... 120 per mi.
Moving plant on job, $500 lump sum.

PLANT FOR BITUMINOUS MACADAM IMPORTED STONE.

Item.	Interest	Depreciation.	Repairs.
Elevator unloading plant	$60	$100	$150
2 rollers	320	270	140
Hand tools, Plows, Road machine, Scrapers and Wagons as for waterbound macadam.			
3 tar kettles	36	...	30
Total for season, 5 miles	$528	$905	$490
Total per mile	$106	$181	$98

Interest on force account ..... $40 per mi.
Bond charge ..... 30 per mi.
Insurance ..... 100 per mi.
Moving plant on job, $500, lump sum.

PLANT FOR BITUMINOUS MACADAM LOCAL STONE.

Item.	Interest.	Depreciation.	Repairs.
1 traction engine	$72	$150	$100
1 crusher outfit	100	220	400

Rollers, Hand tools, Plows, Road machine, Scrapers, Wagons and Tar kettles as for imported stone.

1 steam drill and bits	10	50	80
1 portable boiler for drill	12	30	20
Total for season, 5 miles	$667	$1,270	$950
Total per mile	$133	$254	$190

Interest on force account ..... $50 per mi.
Bond charge ..... 25 per mi.
Insurance ..... 120 per mi.
Moving plant on job, $500, lump sum.

Forms for Estimates.

The following form of estimate for one mile of road has proved very satisfactory. The item of 6% on materials is used to cover demurrage and interest on money tied up on freight and stone. The other items of profit are what we consider a reasonable return for the risk of such contract work. Mechanical hauling is not considered, as so few contractors own plants that make it possible.

STANDARD ESTIMATES.

Figured on the basis of 20% profit on labor, 6% on materials, 6% on money invested, and an allowance made for depreciation on different plants as shown above.
Labor at $0.175 per hour
Teams at $0.45 per hour

EARTH EXCAVATION.

Class.	Amt. per mile.	Price per cu. yd.
Easy	3,000—5,000 cu. yds.	$0.45
Easy	1,500—3,000 " "	0.50
Average	3,000—5,000 " "	0.50
Average	1,500—3,000 " "	0.60
Hard	3,000—5,000 " "	0.60
Hard	1,500—3,000 " "	0.70

ROCK EXCAVATION.

	Price per cu. yd.
Large boulders (for which 10 cu. yds. a mile are allowed on all estimates)	$1.50
1. Steam drill work, limestone	1.25
1. Steam drill work, granite	1.50
2. Hand drill work, limestone	2.00
2. Hand drill work, granite	2.00
1. Large quantities	...
2. Small quantities	...

FIELD STONE SUB-BASE.

A sub-base course 6 ins. deep made of the usual size fence stone requires 1 cu. yd. loose for 1 cu. yd. rolled.
1.2 ins. deep requires 1.25 cu. yds. loose.

Cost of cobbles per loose cu. yd.	$0.10	Multiply these items by 1.25 for 12-in. depth of sub-base.
Loading cobbles per loose cu. yd.	0.15	
Hauling cobbles 1 mile per loose cu. yd.	0.33	
Placing cobbles per loose cu. yd.	0.10	
Rolling cobbles per loose cu. yd.	0.05	
Filler (see below).		
Total	....	
20% Profit	....	
Estimate	....	

FILLER.

⅛ cu. yd. per cu. yd. rolled sub-base.

Cost ⅛ cu. yd. at pit or crusher	....
Loading ⅛ cu. yd.	$0.05
Hauling ⅛ cu. yd. 1 mile	0.10
Spreading ⅛ cu. yd.	0.04
Total	....

SUB-BASE BOTTOM COURSE.

Same relation of loose and rolled quantities as for sub-base.

Cost fence stone per loose cu. yd.	$0.10
Loading fence stone per loose cu. yd.	0.15
Hauling 1 mile per loose cu. yd.	0.35
Placing and sledging	0.20
Rolling	0.05
Filler (see below).	
Total	....
20% Profit	....
Estimate	....

FILLER.

⅛ cu. yd. per cu. yd. rolled sub-base.

Cost ⅛ cu. yd. at pit or crusher	....
Loading	$0.05
Hauling per mile	0.10
Spreading and brooming	0.08
Total	....

IMPORTED BOTTOM STONE.

MATERIALS.

3-in. course, 3,050 lbs. f. o. b. crusher	....
4-in. course, 3,150 lbs. f. o. b. crusher	....
6% profit	....
Total	....
Freight on stone to delivery point	....
Total No. 1	....

LABOR.

Unloading.	
Under 2,000 cu. yds. (shovelling)	$0.15 per cu. yd.
Over 2,000 cu. yds. (elevator)	0.10 per cu. yd.
Hauling (Teams).	
Bad conditions	$0.35 per yd. mile
Average conditions	0.30 per yd. mile
Good conditions	0.25 per yd. mile
Mechanical hauling	0.15 per yd. mile
Spreading.	
5½ ins. loose depth	$0.06 per cu. yd.
4½ ins. loose depth	0.08 per cu. yd.
Rolling	0.05 per cu. yd.
At this point total up and add 30% of the total to change the estimate from loose to rolled measure.	
Filler (see below)	....
Labor total	....
20% profit	....
Total No. 2	....

FILLER.

Cost of 0.35 cu. yd. at pit or crusher	....
Loading, 0.35 cu. yd.	$0.05
Hauling 0.35 cu. yd. 1 mile at $0.35 per yd mile	0.12
Spreading and brooming 0.35 cu. yd.	0.07
Filler Total	....

SUMMARY.

Total No. 1	....
Total No. 2	....
Interest and depreciation	....
Estimate	....

IMPORTED TOP STONE WATERBOUND MACADAM

MATERIALS.

4,450 lbs. stone f. o. b. crusher	....
6% profit	....
Total	....
Freight on stone to delivery point	....
Total No. 1	....

LABOR.

Unloading (same as bottom)	....
Hauling (same as bottom)	....
Spreading	$0.08
Rolling	0.04
Puddling	0.06
Total loose measure	....
Add 30%	....
Total rolled measure	....
Screenings see below	....
Total	....
20% profit	....
Total No. 2	....

SCREENINGS.

*Unloading 0.5 cu. yd.	$0.07
Hauling 0.5 cu. yd. 1 mile	0.15
Spreading 0.5 cu. yd.	
By cross dump wagons	0.03
By hand	0.07
Total	....

*Screenings are usually unloaded by hand.

SUMMARY.

Total No. 1	....
Total No. 2	....
Interest, depreciation, etc	....
Estimate	....

IMPORTED TOP STONE BITUMINOUS MACADAM

MATERIALS.

2-in. course, 4,350 lbs. f. o. b. crusher	....
3-in. course, 4,050 lbs. f. o. b. crusher	....
6% profit	....
Total	....
Freight on stone to delivery point	....
Total No. 1	....

LABOR.

Unloading (same as above)	....
Hauling (same as above)	....
Spreading No. 3 stone (same as above)	....
Total	....
Add 20% for 2-in. course, 30% for 3-in. course	....
Total No. 2	....

MANIPULATION OF NO. 1A AND NO. 2.

Spreading and brooming No. 1A and No. 2 per cu. yd. rolled top course.

For 2-in. top, 0.20	$0.20
For 3-in. top, 0.10	0.10
Manipulation of Bitumen including rolling at $0.015 per gal	....
Total No. 3	....
Total No. 2	....
Total	....
20% profit	....
Total No. 4	....

SUMMARY.

Total No. 1	....
Total No. 4	....
Interest, depreciation, etc	....
Estimate	....

LOCAL STONE MACADAM.

Field Stone.

1 cu. yd. field stone = 1 cu. yd. crushed.
1.8 cu. yds. field stone = 1 cu. yd. No. 3 and 4 rolled.

Cost 1 cu. yd. field stone	$0.10 per cu. yd.
Blasting or sledging per cu. yd. actually blasted or sledged	0.40 per cu. yd.
Loading 1 cu. yd. field stone	0.13 per cu. yd.
Hauling 1 mile field stone	0.35 per cu. yd.
Crushing 1 cu. yd. field stone	.... per cu. yd.
Sandstone (soft)	0.10 per cu. yd.
Limestone	0.15 per cu. yd.
Granite and trap rock	0.20 per cu. yd.
Total cost in bins (loose, including Nos. 1, 2, 3 & 4 stone)	.... per cu. yd.

QUARRIED STONE.

Limestone, quarrying	$0.50 per cu. yd.
Conglomerate, quarrying	0.80 per cu. yd.
Trap, quarrying	0.70 per cu. yd.
Crushing (same as above)	.... per cu. yd.
Total cost in bins	.... per cu. yd.

The crushing cost does not include repairs to crusher.
The crushing is taken from previously given cost data.
The item of quarrying includes delivering to crusher.

ESTIMATE OF BOTTOM STONE.

Cost in bins	....
Loading	$0.01 per cu. yd.
Haul (same as bottom)	....
Spread (same as bottom)	....
Rolling (same as bottom)	....
Total (loose measure)	....
Add 30%	....
Total (rolled measure)	....
Filler (same as bottom)	....
Total	....
20% profit	....
Total No. 1	....
Interest and depreciation	....
Estimate	....

LOCAL STONE TOP.

Cost in bins	....
Manipulation same as for imported stone	....
Total	....
20% profit	....
Total No. 1	....
Interest and depreciation	....
Estimate	....

IMPORTED NO. 2 STONE, ESTIMATED LOOSE.

Material.

2,400 lbs. stone	....
6% profit	....
Total No. 1	....
Unloading same as bottom	....
Haul same as bottom	....
Spreading	$0.10
Total	....
20% profit	....
Total No. 2	....
Total No. 1	....
Total No. 2	....
Estimate	....

LOCAL NO. 2 STONE.

Cost per cu. yd. in bins	....
Haul same as above	....
Spreading same as above	....
Total	....
20% profit	....
Estimate	....

UNIT PRICES MINOR ITEMS.

Third-class masonry cement joints	$6.00 per cu. yd.
Second-class concrete	9.00 per cu. yd.
Third-class concrete	7.00 per cu. yd.
Pointing old masonry	0.75 per sq. yd.
Rip Rap	1.50 per cu. yd.
Paving cement joints	1.50 per sq. yd.
Cobble gutter	0.50 per sq. yd.
Expanded metal	0.10 per sq. ft.
Guard rail	0.30 per lin. ft.
2-in. pipe rail	1.50 per lin. ft.
Concrete guard rail	0.50 per lin. ft.
Cast-iron pipe	35.00 per ton.
*6-in. V. T. P. in place	0.30 per lin. ft.
12-in. V. T. P. in place	0.60 per lin. ft.
15-in. V. T. P. in place	0.90 per lin. ft.
18-in. V. T. P. in place	1.10 per lin. ft.
24-in. V. T. P. in place	2.00 per lin. ft.
Relaying old pipe	0.10 per lin. ft.
4-in. farm tile underdrain in place	0.10 per lin. ft.
Steel in place	0.06 per lb.
Oak timber in place	50.00 per B.M.
Hemlock timber in place	40.00 per B.M.
Danger signs	2.00 each
Guide board posts	6.00 each
Highway No. signs	1.00 each
Guide signs per letter	0.15 each

*V. T. P. = Vitrified tile pipe.

Influence of Work and Finishing Temperature on the Physical Properties of Steel.

By THOS. H. JOHNSON.*

In the Report of "Tests of Metals" at the Watertown Arsenal, 1909, Vol. 3, p. 870-896, there appears a series of tests of open-hearth steel from a hexagonal ingot forged down into bars with different amounts of reduction under the hammer and at different finishing temperatures. The results are summarized in tabular form on page 896 of the Report. The Report presents no discussion of the results obtained. The writer was led to make a study of them on his own account, and ventures to present here the result of his study.

The series of tests consists of five groups finished at temperatures of 1400°, 1600°, 1800°, 2000° and 2200° F., respectively. Each group consists of five individual tests (except that at 2000°, which contains six tests) in which the metal had undergone different amounts of reduction under the hammer, that is to say had been subjected to different amounts of work.

INFLUENCE OF FINISHING TEMPERATURE.—From Fig. 1 it would appear that the ultimate strength is approximately constant under all conditions of finishing temperature; while the elastic limit is quite markedly dependent on the temperature. On the other hand the elongation and reduction in the tensile test show a close relation to the amount of work, and are apparently uninfluenced by the temperature.

In addition to the data of the table, the relation of elastic limit to ultimate strength has been computed and platted. It will be noted

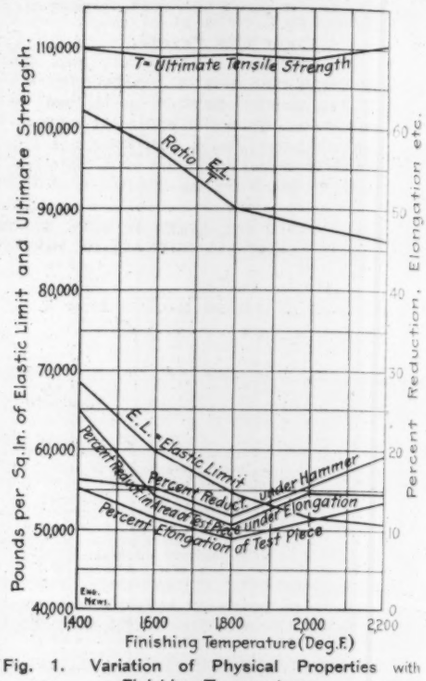


Fig. 1. Variation of Physical Properties with Finishing Temperature.

(The points of the curves are the group averages, five tests per group except six for 2,000°.)

that this ratio decreases from 62% when finished at 1400°, to 50% at 1800° and to 45% at 2200°. Hence it would appear that, in the ordinary tensile tests, a low elastic limit relative to the ultimate may be taken to show that the metal has been finished too hot.

INFLUENCE OF WORK.—It will be borne in mind that the comparisons of Fig. 1 are with

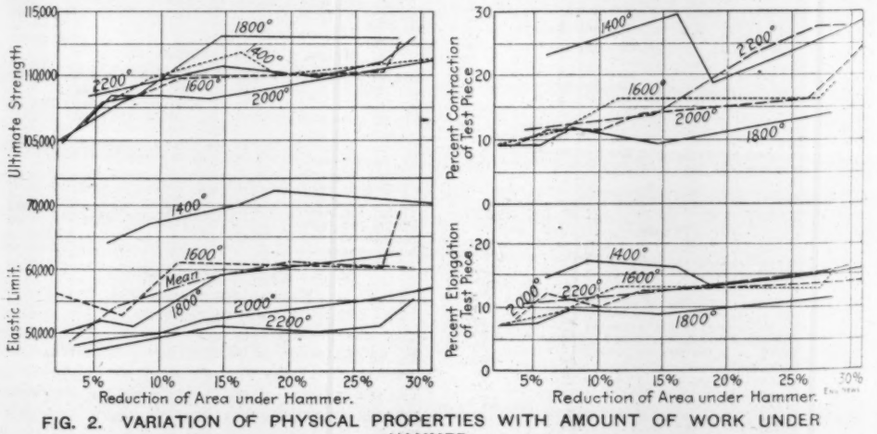


FIG. 2. VARIATION OF PHYSICAL PROPERTIES WITH AMOUNT OF WORK UNDER HAMMER.

(The individual test-results are represented.)

In order to trace the relative influence of work and temperature, the numerical data were put into the form of graphic charts, given herewith as Figs. 1 and 2. In Fig. 1 the means of each group have been platted with the *finishing temperatures* as abscissas. In Fig. 2 the individual tests have been platted with the *reduction under the hammer* as abscissas.

the *mean results* of the several groups. The actual influence of work is more specifically brought out in Fig. 2. Turning to this we note:

The ultimate strength shows a marked increase with increase of work up to about 15% reduction under the hammer, and is but slightly affected by further work.

The elastic limit shows a continuing increase, but at a decreasing rate.

The elongation shows a rather marked increase

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up to about 12% hammer reduction, and thereafter continues to increase uniformly, but at a less rate than before.

The contraction of test piece, if the apparently erratic tests at 1400° are ignored, appears to increase at a nearly constant ratio.

The Report does not state the chemical composition and the only information given is that it was a "hexagonal ingot of open-hearth steel." But all the tests were from a single ingot, and were therefore as nearly uniform in composition as can be obtained, and the comparative effect of work and heat treatment may be accepted as free from any radical complications on account of varying chemistry.

It should be noted that these experiments represent work under a steam hammer, and the results of work in the rolls may or may not be the same. But I think it is safe to assume that in the latter case the influence of work on the several physical properties will be similar in kind, though perhaps differing in degree.

Needed Improvements in the Art of Testing Materials; The Outlook for Uniform International Specifications for Materials.*

By HENRY M. HOWE,† Prest. Am. Soc. T. M.

The justification for the existence of any society, indeed the justification for the existence of any being, is the service it renders to mankind. What, then, is our great service, and how may we increase its value to our fellows?

By setting up standard specifications to serve as standards of reasonableness, of what is just and proper, of what safeguards the buyer with the least hardship to the maker, we do two things.

First, we teach both parties what specific qualities each given product needs in order that it may best fit its use.

Second, we help maker and buyer to agree. We find them, human fashion, each glaring fixedly at that side of the gold-and-silver shield which faces them, one firm in his belief that it is gold, the other swearing that it is silver. Having looked the shield all over, we induce each to take a peep 'round the corner, and see its other side.

We do our share of the great work of the twentieth century, the substitution of cooperation for combat. Of the many ways in which our service may be made more fruitful, let me dwell on two: making firm our very shaky foundations, and paving the way for international specifications.

THE PRESENT CONDITIONS OF THE FOUNDATIONS OF TESTING.—The shakiness of our foundations is only too evident. In order to determine whether a given steel is fitted for a given use, for instance for rails, we prescribe certain reception tests, the conditions of which are very far removed from the conditions under which that steel is to do its work.

A rail must needs resist severe dynamic stresses, severe friction which tends to wear away its upper surface, and severe peening, that is to say, distortion of the upper surface by the pressure of the wheels; and it must continue to endure these things even after the distortion, both by friction and by peening, have radically changed the properties of its upper surface.

The fitness of a rail for these conditions may be determined either scientifically or empirically, or by both means, using one to check the teaching of the other. To proceed scientifically we must determine, first, the exact nature of the stresses, their intensity, and the mode of their application and the nature, severity, and effects, both of friction and of peening. All that is only the first step. As a second step we must next determine quantitatively the relative power of different steels and different sections to endure each of these several things; and forecasting thus the expectation of life which corresponds to each of the various different compositions, microstructures, and sections considered, we calculate by means of the higher mathematics what rail is the cheapest, the cheapest all things considered, including absolute safety within the proposed life, interest charges for relaying, etc.

To state the case is to confess that we are wholly unable to solve the problem scientifically. Though much has been done in the way of measuring the stresses, we have as yet little quantitative knowledge of the effects of friction and peening. But when we come to the second of the two steps, the quantitative forecasting of behavior in service by means of laboratory tests, matters are much worse off. First we have most insufficient light on the relative power of different compositions, microstructures, and sections to endure severally the individual requirements of service; and beyond this we have no means of determining that power except by actual service trial. How little we know scientifically about the properties which our steel must have to endure these individual requirements is shown strikingly by the fact that our most learned, most competent, most broad-minded and best informed authorities have, at least till lately, disagreed radically on so simple and fundamental a question as this: "Does hardness, as such, or high ductility with the softness with which it now seems inseparably united, give the better resistance to abrasion?"

Here, then, is one matter to which I call your attention earnestly. Before we can solve scientifically such problems as these with which we have to do we must devise laboratory tests the results of which shall be convertible into terms of power to endure the several conditions of actual service.

This we are trying to do. Dissatisfied with the irrelevancy of our static tensile test, we are trying impact and endurance tests, with plain and notched bars, and under divers conditions. The results are to be awaited with the greatest interest; but we should recognize the great difficulties which lie before us, and scrutinize very searchingly the credentials of any new test.

TESTS TO DETERMINE USEFULNESS.—My chief purpose in referring to these facts, which are far more familiar to most of you than to me, is to call attention to the importance of the empirical method of solving our problem, and more particularly to a difficult but probably valuable way of making our empirical methods more instructive. Rankine refers, apparently with approval, to the empirical determination of the proper planning of chimneys "by the observation of the success and failure of actual chimneys, and especially of those which respectively stood and fell during the violent storms of 1856." However confident we may be that we shall one day have laboratory tests the results of which shall be directly convertible into the power to perform each of the several distinct duties which a rail, an eyebar, an axle, or other object has to discharge, the difficulties in the way are so great, the distance we have traveled is so slight compared with that which lies beyond, that for a very long time we must rely to a great extent on empirical methods, remaining in the dark as to why it is that such or such specific test is needed and suffices.

The method to which I wish to call your attention is the analysis of existing data, and the accumulation hereafter of data available for analysis, to show which, among the various qualities which we now or may later determine, are most truly indicative of service usefulness. Take, for instance, elongation and contraction of area; there are those who pin their faith on one, and those who swear by the other as the only true measure of the ductility useful in service. Again, of the four properties, tensile strength, true elastic limit, proportionality limit, and yield point, we ought to know which is most truly indicative of power to undergo the stress of any given actual service. Discussions of the relative merits of these properties too often overlook the fact that their value depends solely on the trustworthiness of their indications of service utility, which to-day might be shown more conclusively by an analysis of existing data than by theoretical reasoning.

THE IMPORTANCE OF INTERNATIONAL SPECIFICATIONS.—In retiring from this high office nine years ago I urged on you the great importance of this subject. Nine years have only strengthened the convictions which I then expressed. But they have impressed me with the difficulties, the very serious difficulties, in the way. They may be divided into the difficulties of inertia, those of friction, and those of principle. The difficulties of friction and of inertia are like those of wave and fog which the steamer must needs master; the difficulties of principle are like the hurricane which the wise navigator avoids.

By the difficulties of inertia I refer to the general unwillingness of men as a whole to adopt any new thing. Every change as a change is unwelcome, because it sets before each of us yet another thing to which he must learn to adjust his ways.

The maker of unusually pure material, whose established business and reputation are an asset of great value, fears that the erection of standards may lessen the value of these assets by tending to steer the buyer into relying more on his own knowledge in measuring the extra value of the better quality. But if he really believes in himself and his goods, he should welcome such standards as a measure by which their superiority may be the more readily verified.

The difficulties of friction consist in part of the real harm which will be done to individual concerns, manufacturers, importers, brokers, testing engineers and others, by the erection of standards of reasonableness, by the process of re-adjustment to changed conditions, and by the letting in of light. The direct interests of these individual persons and concerns often seem opposed to the general welfare of mankind.

There are those who, because of the misfortunes either of their character or of their environment, aim primarily to thrive, not through the fitness of their goods, not through their true service, but through cheapness reached through a sacrifice of quality which is not to the buyers' true interest. He who would fain profit by the buyer's ignorance and prejudice, by the salesman's specious argument and half truth, is opposed to setting up standards of reasonableness and to letting in light in general.

These are against us. Who, then, are for us?

First, the small number of manufacturers whose character and environment permit them to serve the consumers' best interests by supplying the fittest goods; second, the far greater number, the consumers themselves; and third, the incalculably greater number, mankind as a whole, the public which we all serve directly or indirectly, the public whose true interest is that each of its servants shall be supplied with the fittest goods.

We should not be discouraged by the impression which a superficial glance gives us, that those whose immediate interests are against us are keenly touched and hence unite in active aggressive resistance, whereas the enormous mass of our beneficiaries, each of whom is affected but slightly, is apathetic; we should not say, "What profits it that millions bless us if they will not lift their fingers against the hundreds who would overwhelm us?" To say this is to be blind to the character of this century and to the qualities of the manufacturers who belong on our side, and of the consumers.

The strength of the manufacturers whom, if we are fit for our task, we can bring into alliance, is enormous; the strength of the buyers whose support we should enlist is incalculable. If we but show ourselves worthy leaders the stars in their courses fight on our side.

Look at these manufacturers, and look at the trend of this century away from the old piratical idea that the buyer was the seller's reasonable prey, to the new idea that he is the seller's employer. If we choose a high enough point of view, and realize that it is but a few centuries since our savage forefathers were cudgeling each other to death on the shores of the North Sea, while before us stretch untold millions of years in which the progress of civilization will surely be ever faster and faster—if we take this point of view, we see that this movement from piracy towards cooperation has in a broad sense only just begun. The power and position into which it has already put such men as Charles B. Dudley, John Fritz, Judge Gary, James Douglas, Charles Kirchoff and Edgar S. Cook should show us the force of this movement even in this its early stage, and how irresistible it will become.

Look at our third great ally, the public. This same universal education is fast lifting up the great mass of mankind from the old position of the servants of the well-born and strong, the recipients of conditions imposed by their masters and of laws doled out by their lawmakers, to the position of the watchful masters of the lawmakers. This movement has spread beyond our Aryan race till to-day no important unlimited monarchy remains anywhere in the world. Think how lately the first important modern republic was founded.

See how even in these relatively early days of the passage of the public from the position of recipients toward that of masters they have enforced their demands for purity of food and of drugs; note their attitude when they thought their demands for conservation were not duly regarded; note how they have enforced, through most of the world, their demand that the welfare of the masses shall be cared for, whether by the protection of the worker from needless bodily dangers, or by the protection of the young and helpless of either sex from needless perils to character, or by placing the risks of hazardous occupations on those who organize them and profit by them. This is the public, already enlightened and watchful, and fast increasing in intelligence and watchfulness, to which our appeal lies for help and support in our work of helping it to get the fittest goods, by erecting reasonable standards for judging the fitness of those goods.

INTERNATIONAL COMPETITION.—But beyond them lie more serious difficulties in certain directions, the present apparent conflict between the interests of certain important countries as regards certain products. Again let me take the case of rails. The ore conditions of country A force it to use the acid Bessemer process for its rails, and to leave 0.08 per cent. of phosphorus in them; the ore conditions of country B permit it to use the basic Bessemer process and to reduce the phosphorus content of its rails to 0.04 per cent. I use imaginary numbers to fix our ideas. How shall these two agree? How shall country A be brought to admit that its apparent disadvantage is a true disadvantage, or country B that its apparent advantage is illusory? I will not say that it cannot be done; but such conditions make the task of agreeing on international specifications far harder.

In view of this it would seem that the path of least resistance is to choose for the earliest international specifications, not objects the composition of which is determined by the ore conditions of individual countries, as that of rails is; but rather, objects which can readily be given one and the same composition in all the great producing countries.

For instance, among steel objects for the first trials objects should be selected which are currently made by one of the basic processes, and therefore can have their

*Extracts from the Presidential address before the American Society for Testing Materials, at Atlantic City, N. J., June 27, 1911.

†Professor of Metallurgy, Columbia University, New York City.

phosphorus content lowered to any desired point in any country.

Let us look now at some of the steps proposed or taken towards the end of setting up international specifications.

PREPARATION OF INTERNATIONAL SPECIFICATIONS.—In order that a set of specifications shall be international, they must be accepted by the great nations concerned, and hence must be acceptable to those nations. Our choice seems to lie between what may be called the direct and the stamping or indirect method of arriving at international specifications.

The direct method is to select as an entering wedge some object the existing specifications for which differ but little among the different producing nations, and try to draw up a single set of specifications which shall be acceptable to all these nations.

THE "STAMPING" PLAN OF ATTEMPTING TO SECURE UNITY.—The indirect, or "stamping," plan, as I understand it, is first to select, as before, some important object on which agreement should be most readily reached. Second, to create or select from among the several specifications for that object in use in each of the great producing countries a single national specification which is fairly representative of the practice of that country, and therefore is acceptable to it, and to stamp on it an endorsement in the name of the International Association for Testing Materials, certifying that it is representaive of the export practice of that country. This limitation to export practice is made because the chief purpose of international specifications is to facilitate export trade. Third, after these several national specifications shall have been in use long enough to become effective standards, to derive from them a single international specification. Many fear that the plan will not facilitate but oppose final agreement; that it is based on a confusion of ideas, pointing out that the really difficult task is to harmonize, not specifications but men; that you cannot strengthen one set of Nation A's specifications in such a manner that it expels and excludes the others of Nation A without at the same time strengthening it so that it will the more effectively resist the later attempt to displace it in favor of an international specification; that to induce each of the several little scattered bands of country A to throw down its own little standard and unite with the others about a single national standard is to weld them into a compact whole which will fight the more stubbornly and effectively for that standard, not only against the standards of countries B, C and D, but against any standard, national or international, less favorable to their interests.

To this objection it may be replied that education, the broadening of the outlook of those to whom our appeal lies, is the thing most needed for the introduction of international specifications, and that the example of the good done by the adoption of a single standard export specification for each country would furnish a most powerful argument for carrying this same principle one step farther and uniting on a single international specification.

A second objection, a much more serious one, and one of a wholly different nature, urged against the feature of the proposed stamping plan is that it endorses with the authority of the International Association for Testing Materials each of several competing specifications, and that an endorsement, no matter how carefully it is worded and qualified, is after all an endorsement, a ready means of misleading importers in the countries to which we export, especially because their remoteness hinders their recognizing the intended limitations of endorsement.

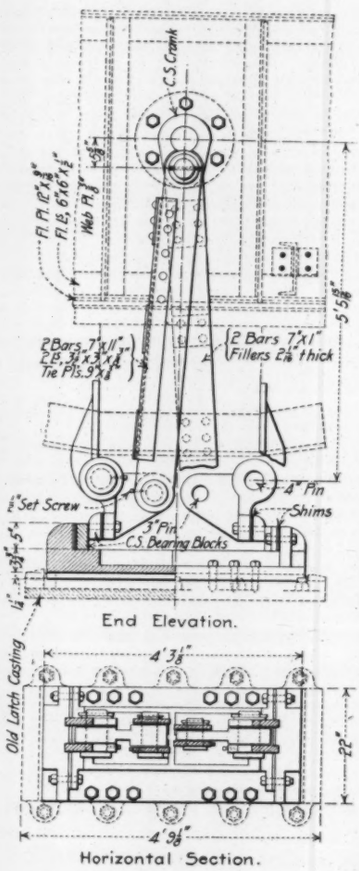
Many believe that any identical endorsement which can be framed must necessarily be open to this objection, that its identity must appear to endorse the products of the several countries as of equal merit.

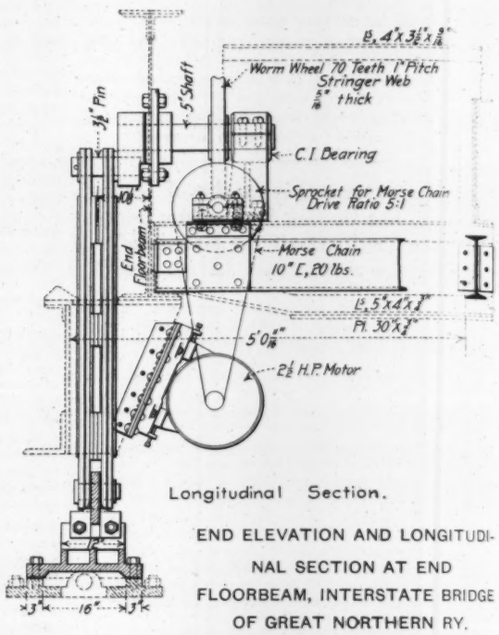
This objection to the plan of identical endorsement furnishes the most serious argument against the stamping plan. In my opinion is must be fully and fairly met before success can be expected. I do not say that it cannot be met. But it is not enough that you and I should be convinced that the wording of a given endorsement could not be used to give undue support to the laxer specifications. The parties in interest in other countries must be convinced. Thus far they have not been. If wording can be devised which would, in the opinion of these parties, be free from this objection, it would remove this, the really serious obstacle to the adoption of the stamping plan. The best way to show that such an endorsement can be devised is to devise it; and as one who has the movement very close to his heart I urge on those who advocate the stamping plan to proceed immediately to remove this objection to it by devising such an endorsement.

Whatever course is chosen, the task is going to be a very difficult one, calling for great patience, tact, breadth of view, and constructive statesmanship; for endless missionary work and endless labor in making our natural allies see that we are serving their true interests and that we are fit for the task we have undertaken. Thus may we get their active cooperation. The problem is not an engineering but a psychological one. The task is to be taken up reverently, with the consciousness that it must tax to the utmost the powers even of the best equipped.

A Lining Device for Swing Bridges; Interstate Bridge of Duluth-Superior Bridge Co. at Duluth.

A distinct departure in swing bridge latching devices was applied to the 500-ft. draw of the Interstate Bridge between Duluth, Minn., and Superior, Wis., two months ago. It has proved very satisfactory in its working, and this fact together with its evident utility of function makes it seem a very promising innovation. It is a device for positively drawing the ends of the span into alinement with the abutments, even though the bridge may be half a foot out of position.




Worm Wheel 70 Teeth 1" Pitch Stringer Web 3/8" thick
5" Shaft
3 1/2" Pin
C.I. Bearing
Sprocket for Morse Chain Drive Ratio 5:1
End Floorbeam
Morse Chain 10" C, 20 lbs.
Pl. 30"x 3/8"
2 1/2 H.P. Motor
Longitudinal Section.

END ELEVATION AND LONGITUDINAL SECTION AT END FLOORBEAM, INTERSTATE BRIDGE OF GREAT NORTHERN RY. AT DULUTH, MINN., SHOWING SELF-ALINING LATCH RECENTLY INSTALLED.

The adjoining drawing of the device as applied to the Interstate Bridge calls for little explanation. In the sketch at the left, a part end elevation of the bridge, an operating shaft carrying a crank is seen projecting through the web of the end floorbeam. Two connecting-rods pinned to this crank actuate two bellcrank-shaped shoes or alining jaws pivoted in brackets under the old landing-shoe of the bridge. The old latch casting on the abutment has a recessed jaw casting bolted over it; the jaws of this casting have steel bearing-blocks bolted to their inner faces. When the operating shaft turns the crank from its upper position to the lower position, the bell-crank shoes are rotated downward and outward, to engage the jaw casting and force the bridge to exact central position.

The shaft is operated by a 2½-HP. electric motor hung from a bracket under the floorbeam, and driving through a sprocket chain and worm gearing. The worm shaft is extended laterally to take a bevel gear, which connects with a vertical capstan shaft for hand operation in emergencies. In fully closed position, the operating crank is at the lower deadpoint; the upper deadpoint is the fully open position. Electrical contacts are provided which inform the operator when the crank has reached its extreme position. In operation, after the draw is lined up and the end lifts and rails are in position, the lining device is raised to be ready for the next operating.

In operation, it was found that when the bridge was left 10 ins. out of line, this alining mechanism drew it to position in 10 sec., using a power of about 1.7 KW. To test the effect of lateral deflection, as would occur under a heavy side wind, shims 1 in. thick were placed back of the bearing blocks of one side; the mechanism brought the structure into line without rise of amperage.

This lining device was designed and installed under the supervision of Mr. John A. Bohland, Bridge Engineer of the Great Northern Railway Co. We are indebted to Mr. Bohland for the drawing and the particulars used above.

A MEANS OF SOFTENING HARD WATER both cheap and effective has recently come into use in Germany on a large scale. The peculiar property of zeolites—which are generally composed of varying quantities of silica, alumina, lime, soda, potash, and water—whereby they can exchange their bases for others, enables them to be utilized as softening agents, and when hard water filters slowly through layers of them the lime in the water changes place with the soda in the zeolites. In Germany there is now being produced an artificial zeolite of a uniform composition, the action of which on water is more certain. Permutit, as this substance is called, is prepared by fusing together felspar, kaolin, clay, and soda in fixed proportions, lixiviating the product in hot water, and collecting the residue. In use as a softener a period must arrive when all the soda in it has been given up and when, of course, its action ceases. It can then be easily regenerated with common salt simply by washing it thoroughly with soft water, and allowing a salt solution of 10% strength to flow through it for four or five hours; the layer of brine is then kept standing on the surface for another four or five hours. In the regeneration process the soda of the sodium chloride replaces the lime in the permutit and becomes converted into calcium chloride, which passes away in solution in the regeneration water. Permutit, it is said, is capable of reducing hardness from 53° to 3.7°. It suffers no apparent loss in working and can be kept in use for very long periods with regeneration every four days or so. In appearance, when in a moist condition, it is of a granular, flaky form with a luster resembling mother-of-pearl. It is of very porous texture, and when dry can absorb 50% of water.—"The Engineer."

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In Jules Verne's story, "The Mysterious Island," which enchanted the boys of a generation ago, the hero was an American engineer who was a walking encyclopedia of technical knowledge relating to every art and industry. He had a correct answer for every question, and promptly found ways of escape for himself and his comrades from every difficulty.

Unfortunately, such engineers live only in fiction; but there still persists in the minds of many people a lingering idea that a great engineer necessarily ought to know everything on every sort of technical matter. It is often humiliating for an engineer to run against this idea, particularly when one finds it in one's own family! A man whose engineering reputation extends across the continent, for example, may be informed at the breakfast table some morning that the hot water drawn into the laundry tubs is so red and muddy with iron rust that the week's washing cannot be done. It is humiliating for the great engineer under such circumstances to have to weakly confess that he neither knows why the hot-water supply so misbehaves nor what to do to remedy it. He has an uneasy conscience that those of his own family who ought to most respect him have their faith in his greatness sadly shaken!

If there be among our readers any engineer who has been stumped by what to a layman seems a very trifling and easy problem—a mere nothing in comparison with the building of a bridge or the design of a locomotive—if there be such an engineer among our readers, he will doubtless read with special interest the paper by Mr. Whipple in this issue detailing the troubles which have occurred in many places with hot-water piping and hot-water supplies.

If we have spoken above as the matter were a trifling one, fit only for jesting, we may amend by saying that it is really one of very great importance in the aggregate. The annual expenditure on repairs of hot-water piping, plus the annual loss from rusty water supplies, doubtless amounts in the aggregate to many millions of dollars in the whole country. A problem of this magnitude is well worth the careful study of members of the engineering profession.

In fact, we might go farther and say that the whole plumbing business as now carried on is full of examples of bad work, bad materials, ignorant design and, in general, enormous outlay in proportion to benefit. Mr. Whipple has laid the foundations for a better knowledge of the situation and better practice in one particular at least. It ought to be followed up by some of the engineering societies, such as the Heating and Ventilating Engineers or the Society for Testing Materials, by the adoption of some sort of specification for piping for hot-water purposes.

A great deal has been published concerning the extent to which, under present-day conditions, the investment in railway terminal facilities and the cost of handling freight at terminals outrun the investment in main line construction and the cost of hauling freight long distances by rail.

When one speaks of terminals, however, the natural thought is of the investment in railway yards and stations and piers and warehouses at the great commercial cities which form the chief reservoirs of traffic, such as New York, Philadelphia and Boston, in the East, and Buffalo, Chicago and St. Louis, in the West. It must be remembered, however, that under the head of terminal facilities must be included not only the enormously expensive terminals at these great cities, but the traffic facilities at local stations, small and great.

An illustration of what is being done in improving railway terminal facilities in cities of comparatively small size is the work recently completed by the New York, New Haven & Hartford R. R. Co. at Waterbury, Conn. The Waterbury "Republican" of May 10, 1911, contains an article describing this work, written by Mr. C. S. Lake, Superintendent of the Western Division, and Mr. Chas. H. Preston, Jr., Resident Engineer. The article describes the work in a much clearer manner than one commonly finds engineering construction described in a daily newspaper.

When the work was undertaken, Waterbury was the center for three or four railway lines originally built as local enterprises and planned with little reference to each other's convenience and economic operation. After all these lines were acquired by the New York, New Haven & Hartford R. R. Co., an extensive revision of all the railway tracks, yards and stations in the city was planned. A fine new passenger station, designed by McKim, Mead & White, was built, and elevated lines took the place of tracks which formerly ran through the streets at grade.

The total area of land used for railway terminals in the city was formerly only 308,000 sq. ft. In the new lay-out the total area is about 1,800,000 sq. ft., or six times that formerly available. The work involved over 1,500,000 yds. of earth excavation, nearly 100,000 yds. of concrete and stone masonry and required the operation of seven steam shovels and 13 working trains for a period of five years. The entire improvements involved an expenditure of $4,600,000.

This is an example of work which is likely to be undertaken in many of the smaller cities of the country during the next quarter century. It will add nothing to the mileage of our railway systems, but will add greatly to the necessary investment and capitalization of our railway companies. Such expenditure is, on the one hand, forced upon the railways by the great development of traffic and the pressure for the removal of grade crossings in city streets, and, on the other hand, it is a wise investment to economize the cost of handling goods at the beginning and end of their journey.

At the close of the last session of Congress we noted (Eng. News, March 16, 1911, pp. 323, 327) the passage of an act authorizing the filling of vacancies in the Corps of Engineers, U. S. Army, by appointments from civil life, in case the qualified number of graduates from West Point would not bring that Corps up to its full quota. It now appears that the recent graduating class at the Military Academy was so small as to provide an insufficient assignment of officers to the engineering branch of the service, in consequence of which there are now about ten vacancies in the Corps of Engineers, which are to be filled by civilian appointment. According to the law, a candidate for such an appointment must be "an unmarried citizen of the United States, between the ages of 21 and 29, who holds a diploma showing graduation in an engineering course from an approved technical school, and is eligible for appointment as a junior engineer under the Engineer Bureau of the War Department."

The Chief of Engineers now has under consideration the rules and regulations under which these appointments are to be made and will soon issue an announcement covering the entire matter. When such announcement is made, we will be pleased to give it the fullest publicity, but at present we wish to do no more than to call attention to this new opportunity for young graduate engineers. The Engineer Corps of the United States Army is not a highly paid body of men, but it offers an honorable and dignified position with the advantage of a broad field of activity and an assurance of a life competence, both during active service and after comparatively early retirement. Never before has it been open to any but the honor graduates of the Military Academy, and we feel sure that the present opportunity will prove attractive to many bright young engineers.

In addition to the openings in the Engineer Corps, it is announced that there are about 30 vacancies in the Coast Artillery Corps and about 150 in the Mobile Army, which are also to be filled from civil life. These commissions do not carry the same attraction to the engineer, but at the same time the requirements for appointment are not so rigid. We know of no training, other than that received at the Military Academy, which should prove a better foundation for an officer in the army than that received at the technical school. Young graduates of such schools who are not entirely satisfied with their prospects in the field of engineering, might do well to look further into the advantages of this line of work.

Many people find it difficult to understand how the value of the dollar can vary when one standard weight of gold is fixed by law as constituting a dollar. The answer given in treatises on economics, of course, is that gold is a commodity and, like any other commodity, its value varies according to supply and demand. The most satisfactory explanation, however, is the practical one that the value of the dollar is always measured by what it will buy, and that if prices rise so that a dollar will buy only three-quarters as much at one time as it did at some former time, the value of the dollar has been actually reduced by 25%.

A bulletin just issued by the Department of Commerce and Labor, showing relative average wholesale prices of commodities for the years from 1890 to 1910, gives an interesting tabular exhibit of the great variation in prices and in the purchasing power of a dollar's worth of wages that has taken place during those years. The average is based upon the wholesale price of 257 different commodities.

RELATIVE WHOLESALE PRICES OF RAW AND MANUFACTURED COMMODITIES AND OF ALL COMMODITIES CONSIDERED, 1890 TO 1910.

(Average price for 1890-1899 = 100.0.)

Year.	Raw commodities.	Manufactured commodities.	All commodities.
1890	115.0	112.3	112.9
1891	116.3	110.6	111.7
1892	107.9	105.6	106.2
1893	104.4	105.9	105.6
1894	93.2	96.8	96.1
1895	91.7	94.0	93.6
1896	84.0	91.0	90.4
1897	87.6	90.1	89.7
1898	94.0	93.3	93.4
1899	105.9	100.7	101.7
1900	111.9	110.2	110.5
1901	111.4	107.8	108.5
1902	122.4	110.6	112.9
1903	122.7	111.5	113.6
1904	119.7	111.3	113.0
1905	121.2	114.6	115.9
1906	126.5	121.6	122.5
1907	133.4	128.6	129.5
1908	123.5	122.2	122.8
1909	136.8	123.9	126.5
1910	139.7	129.6	131.0

It will be seen from the table that a great drop in prices occurred in the years of 1890 to 1897. This was followed by a rapid recovery and during the years from 1900 to 1905 prices returned to about where they were in 1890. In 1906 an unprecedented advance in prices occurred, interrupted only slightly by the depression of 1908 and reaching a maximum in 1910. Quoting the figures from the table, it appears that 90 cts. would purchase as much in the year 1897 as $1.32 would in the year 1910. The effect of this enormous variation upon wages and salaries should be taken into account by every engineer in making computations and studies in which prices extending over a term of years are involved.

An Engineering View of the Pending Reciprocity Arrangement With Canada.

Engineering News is not a forum for the discussion of questions purely political in character. The question of reciprocal trade relations between Canada and the United States, however, is one of economics, of engineering, of transportation and of manufacturing industry more than it is (or rather should be) a question of politics.

In all the discussion concerning reciprocity which has taken place, nothing has been said concerning the geographical and topographical conditions which make trade between the different parts of Canada and the parts of the United States adjacent to them particularly easy and advantageous and trade of the different parts of Canada with each other exceedingly costly.

Few people in the United States realize the extent to which topographical conditions divide the Canadian nation into separate parts, remote from each other, each of which finds its natural commercial relations with the part of the United States immediately south of it, rather than with other portions of the Dominion.

The first of these great divisions of Canada is the Maritime Provinces, Nova Scotia and New Brunswick. These are separated from the trade centers of the Province of Quebec, their nearest Canadian neighbor on the westward, by a distance of over 500 miles. The distance from Halifax to Montreal by the Intercolonial Railway is 837 miles, and the road traverses hundreds of miles of almost uninhabited country in the district lying near the mouth of the St. Lawrence River. By the shorter cut across the State of Maine built by the Canadian Pacific Railway some twenty years ago, the distance from St. Johns to Montreal is nearly 500 miles. The water route from the Maritime Provinces to Quebec by way of the St. Lawrence River is over 1,000 miles in length, and is subject to great risks of fog and ice.

On the other hand, the Maritime Provinces are at all seasons of the year in quick and direct communication both by water and by rail with Boston and New England markets. The natural trade of the Maritime Provinces, therefore, is with Maine and Massachusetts and Rhode Island.

The Canadian financial and commercial centers are the cities of Ontario and Quebec, and the bulk of the manufacturing industries of the Dominion, with the greater part of the population, are also located in these provinces. The natural trade of this section of Canada is with New York, Ohio, Michigan and other sections of the United States lying immediately to the south. The difficulties of trade by Ontario and Quebec with the Maritime Provinces have just been noted; and in order to reach that great fertile section of the Northwest, of which Winnipeg is the center, a railway journey of 1,300 miles from Ottawa must be made. For most of this distance the railway runs through the barren, uninhabited district lying to the north of Lake Superior.

The wonderfully fertile and prosperous section of the Dominion lying in the Central Plains district promises to become one of the greatest wheat growing sections of the world. It is increasing in population and wealth at a phenomenal rate, and one of the great economic problems of the present day is how the produce of this vast and fertile section can be cheaply transported to market.

The barrier of distance between this Northwest region and Ontario has just been noted. In order to obtain a shorter outlet for products of the Northwest sent abroad, the Canadian Government is now undertaking to build the Hudson Bay Railway—a scheme which will have to cope with unprecedented weather conditions in order to win success. The natural channel of trade for all this great section, destined to support a future population of many millions, is with the Middle West district of the United States—with the cities of the Great Lakes and of Minnesota and Dakota.

Crossing over to the Pacific Coast, there is a narrow belt of territory lying to the west of the Rocky Mountains which is separated from the Plains district by nearly 1,500 miles. Its natural trade is with the districts of Washington and Oregon, lying only a short distance to the south.

If natural economic laws had been allowed to work unhindered, and if no higher tariff walls had been erected between Canada and the United States than those which existed at the middle of the last century, an enormous trade, vastly profitable to both countries, would have grown up between each of these various sections of Canada and that section of the United States immediately adjacent. To a considerable extent this natural growth has been prevented by the tariff policy which the United States has adhered to ever since the Civil War.

With these natural trade channels thus obstructed by tariff walls, the Canadians have bravely made the best of the situation and have undertaken the creation of great national highways, both by rail and by water between the East and West. The Canadian policy of government subsidies to railways and great expenditure upon waterways has been practically forced upon the country through the artificial barriers erected across the natural channels of trade.

Great credit is due to the Canadian Government and to Canadian engineers for the work they have done in overcoming these natural obstacles; but no skill of the engineer, and no amount of investment by capitalists or by the government can make an artificial trade route the equal of a natural one. The development of Canada, commercial, industrial and agricultural, can be fostered in no other way so much as by opening the natural channels of trade and allowing commerce to flow in them without restriction.

Speaking at the annual dinner of the Canadian Society of Civil Engineers, held at Ottawa in January, 1910, the Editor-in-Chief of Engineering News expressed the belief that the majority of public sentiment in the United States would welcome the removal of all tariff barriers between that country and Canada.

It was not foreseen at that time that a long step would be taken in that direction within a year's time by means of the reciprocal trade arrangement between the two countries, which has been brought forward through the wise statesmanship of President Taft. There seems at this time every prospect that the Reciprocity agreement will receive at an early day the sanction of Congress, and it is hoped that similar approval by the Canadian Parliament may shortly follow.

It is true that the present reciprocity treaty does not give complete freedom of trade between the two countries; but it is a long step in that direction, and with public experience of the benefits of such commerical exchange, there is little doubt that popular sentiment will in no long time favor the tearing away of the rest of the tariff barriers.

There is no more reason to doubt that the United States as well as Canada would benefit by such an extension of the field of trade than there is to doubt that it is a benefit to have no tariff barrier to obstruct trade between New England and the Middle States, or between Illinois and Iowa, or between the cotton growers of the South and the textile mills of the North.

We are aware that the Reciprocity treaty is opposed by some of the Canadian manufacturers in Ontario and elsewhere on similar grounds to those long used to bolster up the protective system in the United States. It is said that Canada ought to develop its own manufacturing industries, and not rely upon the United States for manufactured goods.

But there is reason to believe that if all artificial barriers to trade between the two countries were removed, Canadian manufacturing industry might find even greater prosperity than at present. A manufacturing plant in Canada could find markets south of the border and not be limited as now to a comparatively narrow market.

The spread of manufacturing industry in the United States during the past half century, through the operation of natural economic laws is a proof of the fact that manufacturing plants will grow up in prosperous new sections of the country in defiance of competition from the older sections. Up to the middle of the last century the bulk of the manufacturing industry of the United States was concentrated in New England. To-day states like Ohio and Indiana and Illinois, which were purely agricultural states at that time are among the leaders in manufacturing industry. The value of goods produced by Illinois factories in 1909 was $1,918,000,000, according to U. S. Census figures just made public. The spread of manufacturing in the South and the far West has taken place with no artificial stimulus.

Doubtless, there may be cases of temporary individual hardship to Canadian manufacturing enterprises which have been established under the protection of the Canadian tariff; but in the long run manufactures will develop in Canada to a vast extent, even if absolute free trade is established with the United States. Under modern conditions, manufacturing industry goes where a cheap and reliable labor supply is obtainable, where climatic conditions are favorable, where raw materials are convenient of access, where transportation facilities are good. Canada's enormous water power, its advantages of water transportation by the Great Lakes and the St. Lawrence River, its wealth of natural resources in forests, minerals and agricultural products, and its supply of intelligent labor ensure a great future for the Canadian manufacturing industry, regardless of United States competition.

It may not be inappropriate to add that in the after-dinner speech above referred to, the idea was emphasized that commercial union between the two countries ought not to be opposed through any fear that it might be an entering wedge for political union.

Canada can govern itself, and solve its own political problems a great deal better than the United States can solve them for it. The United States has all the political problems of its own that it cares for or can well deal with. Political union of the two countries would be a disaster to both.

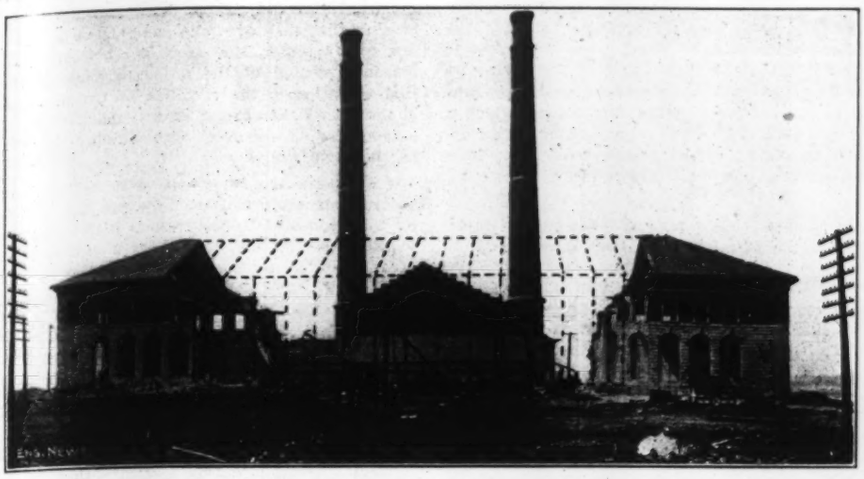
One of the great object-lessons which the United States has taught the world is the advantage of local self-government. Just as the separate states of the Union can solve each its own problems for itself better than they can be solved for it at Washington, so Canada can handle her own internal affairs a great deal better than they could be handled for her either by the National Congress at Washington or by an Imperial Parliament at Westminster.

LETTERS TO THE EDITOR

Collapse of the Porter Ave. Pumping Station Buffalo, N. Y.

Sir: Until District Attorney Dudley, of Erie County, has concluded his John Doe proceeding in the City Court before Judge Hartzel, it is hardly proper to draw conclusions as to causes of and responsibility for the collapse of the Porter Ave. Pumping Station.

Mr. William G. Houck, C. E., President of the Buffalo Structural Steel Co., after examining the wreck testified to the absence of vertical diagonal bracing between the 13 fallen roof trusses, called for by the plans. He also swore that all of the several members of each truss, with only three exceptions, had been reduced from 1/16 to 1/4-in. in section from the sized shown upon the drawings as filed with the Department of Public Works. Mr. Robert J. Reidpath, another structural engineer, confirmed Mr. Houck's testimony.



THE PORTER AVE. PUMPING STATION, BUFFALO, N. Y., SHOWING PORTION REMAINING AFTER COLLAPSE ON JUNE 30, 1911.

Your correspondent has examined these blue prints and noticed other discrepancies. The column construction is entirely different from the plans. The gusset plate shown on the drawings at the connection of the bottom chord with the roof beam seems to have been omitted. This is shown as filling the angle up to the top connection of the knee brace with the bottom chord.

The District Attorney has retained Mr. Willard Brown, of the Garrett-Cromwell Co. of Cleveland, structural engineer, and it is reported that he will also have an out-of-town expert on concrete. Several workmen engaged on the job have stated that the trusses "were bent" some as much as 8 ins., and that many rivets were left out at connections. Examination of the fallen trusses shows a number of bolts where rivets were called for.

Wurtz & Sons, who had the sub-contract for the steel work, having no shops in Buffalo, assembled the trusses in the pit of the building. It does not appear as yet that any thorough structural inspection was made. One of the iron workers testified that as the holes in the steel did not match and there was no reaming gang, they had to get the rivets in as best they could. Although some of the rivets were pretty bad, he did not hear that any were cut out and he never saw a rivet inspector on the work.

In reply to questions of the District Attorney, Mr. Kendig, who was a year ago appointed "overseer of the work" for the Bureau of Water (a Bureau of the Department of Public Works), stated that the supervising architect visited the work for an hour or two each day at first and later, when not so much work was being done, he was there about once a week. There were no other inspectors present at any time so far as he knew. Although the iron work was erected a year ago, he had never reported the absence of vertical bracing between the trusses. He swore that he had never had any previous experience in building operations or structural work and that he was, before this job, Superintendent of a bicycle factory.

The specifications appear to give the Department of Public Works full and complete control of the building yet the Deputy Commissioner of Buildings testified that he had never examined the structure until after its collapse. The supervising architect, who also designed the building, is not a regular employee of the City, but was appointed by the Board of Park Commissioners and Commissioner of Public Works with the recommendation that the construction should be carried on under the inspection of some regular employee of the Department of Public Works. The structure is located upon park property and the Park Board gave permission for such location on condition that it should have certain powers regarding the selection of architect and plans in order that buildings of fine appearance should be secured that would ornament the water front park. The architect's fees have been paid by the Bureau of Water out of moneys due the contractors, his 3½% for plans and specifications being deducted from the first estimate.

The investigation now being conducted by the District Attorney is in reality an inquest to determine the question of criminal responsibility for the death or injury of the unfortunate men caught in the collapse. The Mayor's investigation, which has been suspended during the inquest, is for the purpose of determining the responsibility of the City under the contracts.

The Department of Public Works has posted danger notices on the boiler-house, which is of similar construction to the fallen engine-house, warning all persons to keep out. The roof of this building is very like the fallen one and in it the vertical bracing between trusses, called for by the plans, has also been omitted.

"Correspondent."

Buffalo, N. Y., July 10, 1911.

Sir: The collapse of the roof of the Porter Ave. pump house of the new Buffalo, N. Y., water-works pumping station, briefly described in your last issue has during the week been an all-absorbing topic in this city, all the newspapers printing pages of matter both relevant and irrelevant.

Although it is now over ten days since the disaster occurred no official or authoritative statement as to the cause has been given out as yet. So far three hearings to determine the cause of the collapse have been held, one before the Mayor of Buffalo, Hon. Louis P. Fuhrmann, and conducted by the Hon. Clark H. Hammond, Corporation Counsel, and two before Judge A. A. Hartzell, City Court, and conducted by the Hon. Wesley Dudley, District Attorney.

In the report in last week's issue of Engineering News it was stated that when the roof fell men were engaged in placing the tile which covers the reinforced cinder concrete roof, which is supported directly by the purlins below. This is an error. Tile laying was in progress on the roof, but none were laid after 4.30 o'clock Thursday afternoon, the roof falling at 9.15 o'clock Friday morning, the next day.

The tile were usually hoisted from the engine pit floor by means of a small engine and line to a platform situated in the trusses above, and at the time of the collapse it was rumored that the strains produced by this method of hoisting caused the trusses to fail.

Various theories as to the cause of the disaster have been promulgated, nearly all absurd and ridiculous. The one possessing the most rational merit, is that the trusses lacked longitudinal bracing.

The view herewith is a photograph of the wrecked building, showing a front view. It shows what is left standing of the building, portion of the north and south sides and remaining hipped roofs.

On the photograph is indicated in dotted lines the original position of the fallen trusses. Beginning on the left hand or south end trusses Nos. 1, 2, 3 and 4 are standing, No. 3 being the point of the hip or apex, trusses Nos. 3 and 4 are braced longitudinally by an X-brace on the center line or axis of the building. The dotted lines show trusses Nos. 5 to 19, inclusive; trusses Nos. 20, 21, 22 and 23 are in place, conditions same as Nos. 1 to 4, inclusive.

All of the cinder concrete roof (4 ins. thick) had been placed and more than one-half of the tile roofing had been laid. The work of placing these tiles must have had a tendency to disturb the perpendicularity of the trusses Nos. 5 to 19, inclusive, and may also have produced a swaying motion, like that of a pendulum, which from other causes became more intensified and accelerated until the critical period was reached, when failure occurred, by the roof splitting, falling and drawing in the side columns and attached walls.

"S. C."

Buffalo, N. Y., July 8, 1911.

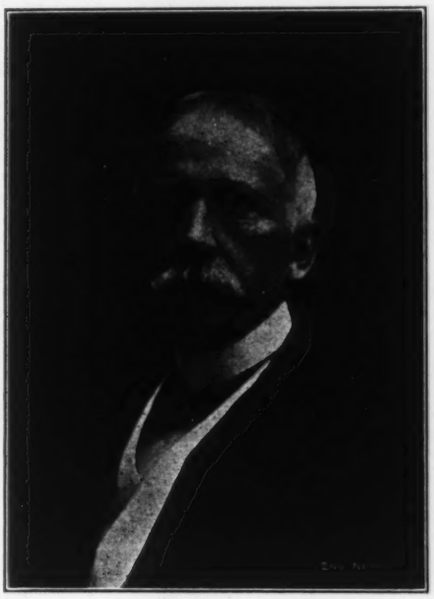
Notes and Queries.

In our issue of May 18, p. 609, in describing the tile pipe testing machine designed by Prof. A. O. Anderson, an error was made in crediting it to Engineering Experiment Station of Iowa State University. The State Engineering Experiment Station is located at the Iowa State College at Ames, Iowa, not Iowa State University, which is at Iowa City. We are advised that blue prints of this machine will be furnished without charge to those desiring to build such a machine, or the machine itself will be furnished at a nominal charge by Mr. Hubert Reidesel, Lanesboro, Iowa, or the Quinn Co., Boone, Iowa.

Theodore Newell Ely.

After forty-three years in the service of the Pennsylvania Railroad Company, Mr. Theodore N. Ely has been retired from active service. Few men have contributed more largely to the development of high standards in railway engineering work in the United States than has Mr. Ely.

Mr. Ely graduated from Rensselaer Polytechnic Institute in the class of 1866, and two years later entered the Engineering Department of the Pittsburg, Fort Wayne & Chicago Ry. He was soon transferred to the Philadelphia & Erie Division of the Pennsylvania R. R., and for four years served in the Operating Department, being Assistant General Superintendent of this division from 1870 to 1873. In the latter year he became Superintendent of Motive Power, in which department of railway service his work thereafter lay. He was transferred in 1874 to the Pennsylvania R. R. Division, and in 1882 became General Superintendent of Motive Power of all the Pennsylvania Lines East of Pittsburg and Erie, with headquarters at Altoona. It was under Mr. Ely's direction that the Altoona shops and offices became the headquarters for the most famous and efficient school of practical railway engineering that has ever existed on any American railway. With the efficient cooperation of the late Dr. Chas. B. Dudley, Mr. Ely educated in the detail work of the railway service a number of young men who in later years became prominent figures among American railway officers.



Theodore N Ely

Since 1893 Mr. Ely has had the title of Chief of Motive Power, with headquarters at Philadelphia, and has been chiefly concerned in the larger problems in connection with the operation of the system as a whole. His work in connection with the Eastern Railroad Association, of which he has long been President, the American Railway Association and other prominent organizations, has been of great value and importance. Mr. Ely holds membership in many engineering societies, including the American Societies of Civil and Mechanical Engineers, the American Institute of Mining Engineers and the Institution of Civil Engineers of Great Britain. Besides his official position with the Pennsylvania R. R., Mr. Ely is a director of the Pennsylvania and Cambria Steel companies and Trustee of the Drexel Institute and Philadelphia Commercial Museum. He was given the honorary degree of Master of Arts by Yale University in 1897 and of Doctor of Science by Hamilton College in 1904.

The Charles River Bridge of the Boston Elevated Railway.

One of the three additions to the rapid transit facilities of Boston, now under construction, is the East Cambridge elevated extension, which connects the Tremont St. subway at the North Station with the present surface tracks at Lechmere Square, East Cambridge, via a steel elevated structure in Boston and a concrete viaduct across the Charles River running down to surface level on a structural steel incline in East Cambridge. At first it is expected only to operate single surface cars over this new line but provision is being made to accommodate heavy elevated or subway trains in the expectation that at some future time an extension may be desired through Cambridge to Harvard Square, there to connect with the Cambridge-Boston Subway, now also under construction.

The most advantageous location for the Charles River crossing of the extension was found to be at the Charles River Dam,* the masonry and earth structure forming the barrier that makes the well-known Charles River Basin, and it was at first hoped that the surface of this dam, now a roadway carrying a highway and surface cars, might be used for the crossing. The Charles River Basin Commission, then in charge of all the improvements connected with the Charles River Basin, refused permission to the company to use the dam for an elevated structure, but allowed it to build a viaduct immediately along side, with the proviso that it was architecturally acceptable to the commission so as to be in keeping with the improvements at the Basin.

Work was started on the foundations of this bridge late in the summer of 1907, and was continued through the three following seasons; the superstructure of the bridge was begun in the spring of 1910, and was continued up till last Fall, to be resumed again this Spring and it is expected that the bridge together with its elevated connections on either side will be completed before cold weather sets in. On account of a peculiar lightness of construction, as well as its size, the Charles River Bridge is of particular interest.

The general outline and location of the bridge is shown in Fig. 1. Starting at the Boston side, it consists of two 98 ft. 4 in. arches, a 70 ft. draw span over the lock into the Charles River Basin, five 122 ft. 4 in. arch spans, a 128 ft. arch span over the sluiceways out of the Basin, two 98 ft. 4 in. arch spans and a 75 ft. plate-girder span over a roadway, a total length of 1738.75 ft. It is 31 ft. wide between parapet faces, carrying two car tracks on an open floor system and two narrow emergency footwalks, to be used only in case of some breakdown of the cars on the bridge. No highway is provided, as the immediately adjacent dam is sufficient for all highway traffic. The construction throughout is of concrete, except the inter-tidal space facing of the piers, which is of granite, the drawbridge, which is of steel, and the plate-girders at the western end, which are of steel covered and protected by concrete.

It will be noted from the drawing (Fig. 1) and from the view in Fig. 2, that the bridge is immediately alongside of the Charles River Dam, the elevation of the roadway on the dam being about the same as that of the springing lines of the arches on the bridge. The level of the tracks is about 37 ft. above high water of the harbor on the downstream side. On account of this proximity to the roadway on the dam, across which a heavy traffic moves, the requirements for an artistic treatment of the bridge, both as to lines and surface, was most imperative.

Piers.

As has been stated in many other articles in this journal the Charles River Dam is an earth-fill between two marginal masonry walls, each supported on piles. The bottom of this masonry wall on the downstream, or harbor, face of the dam is, therefore, some 20 ft. above the solid bottom of the river, the intervening space being composed of fill. It was against this outer wall that the piers for the bridge were placed, with the upstream face of the pier cutting into the dam about 18 ins. and with the masonry base of the lowest pier 30 ft. below that of the dam. These relative positions are shown in Fig. 3.

Investigations of the bottom showed it to consist of the fill for the dam overlaying sand and gravel upon clay growing harder as it went deeper. It was decided to foot the masonry of the piers in this sand and gravel upon piles penetrating down into the clay. The pier bases are all of concrete, 54 ft. wide and varying in length from 39 to 45 ft., depending upon their position in the bridge and the loads from their respective arches. They are founded on timber piles, each designed to bear safely 11 tons and spaced about 2 ft. on centers, as shown in Fig. 3. In the smallest piers 468 piles are used and in the largest 624.

This work was started some years ago and has been completed about two years. It was carried on in open cofferdams, driving piles and cutting them under water and then making the seal with concrete placed through bottom-opening buckets under water. The general design of the piers is shown in Figs. 3-4. From those drawings it will be seen that they are solid concrete up 2 ft. below to low water, that is to the bottom of the masonry section of the adjoining dam. From that elevation to the elevation of the sk[illegible] back of the arches they are of granite masonry [illegible]ing a thin wall of concrete, with a hollow in[illegible]rior, as shown in Fig. 4.

It has been the experience with nearly every concrete structure in Boston Harbor that the inter-tidal space of the concrete is bound to disintegrate most rapidly. The best known instance of this action is the Charlestown Navy Yard piers (Eng. News, Aug. 27, 1908, p. 238) a short distance below the Charles River Bridge. Whether this is purely a physical action, or is due to the peculiar constituency of the water, has not been fully settled, but at any rate it is considered the best practice there not to expose concrete to the wear of the inter-tidal waters. For this reason this space on the piers in the bridge was made with granite blocks. The hollowing out shown on the figure is merely for economy. It will be noted that there is a reinforced-concrete floor slab over the hollow and that an extra reinforced block is provided against which the arch ribs abut.

Pier 4 is very much larger than the standard arch piers, because it has to take the uplift from the bascule draw in addition to the unbalanced thrust of the adjoining arches. Pier 3 is made symmetrical with it, although none of the uplift from the bascule is transferred to it. The marginal sewer, emergency outlets, etc., also pass under Pier 3.

The arch between Piers 9 and 10 had to be made somewhat larger than the others and the piers somewhat deeper and larger to care for the sluiceways which take out of the basin at this location, as shown in Fig. 1.

The face of the dam at each of the piers has been brought up perpendicular at each of the bridge piers so that there would not be a narrow opening there, and the tight joint between the

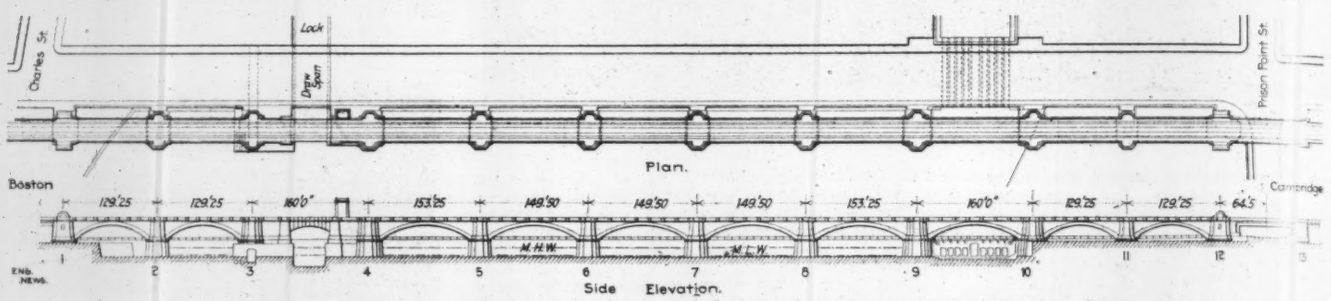
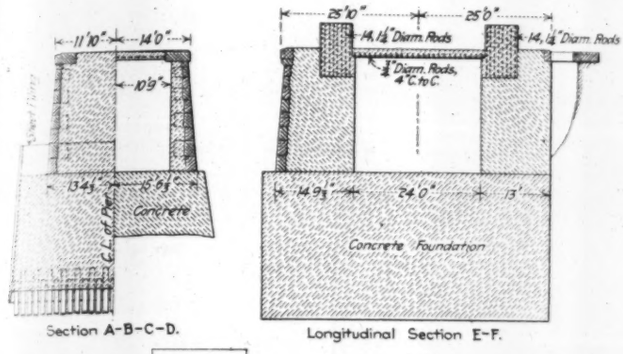


FIG. 1. GENERAL PLAN AND ELEVATION OF THE CHARLES RIVER BRIDGE OF THE BOSTON ELEVATED RY.

FIG. 2. VIEW OF CHARLES RIVER BRIDGE DURING CONSTRUCTION, LOOKING FROM PIER 4 WEST TOWARD CAMBRIDGE.

*A number of articles on the Charles River Dam have appeared in Engineering News; the latest in the issue of March 9, 1911, p. 284, contained a reference list of the earlier ones.



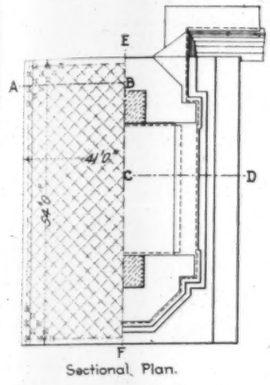


FIG. 3. TYPICAL DETAILS OF THE LOWER PART OF THE REGULAR PIERS.

two pieces of masonry filled with pitch to allow for expansion and contraction.

Piers 12 and 13, at the ends of the plate girder span, are much larger than the arch piers, and are hollow, so that the interior may be used for storehouses.

Arches.

Fig. 5 shows the details of a typical 122-ft. span. Each span is made of two two-hinged arch ribs, spaced 29 ft. c. to c., carrying the roadway on transverse beams with curved bottoms, on which the longitudinal track stringers rest. The design is notable for its lightness, approaching in that respect the typical details of steel arch bridges.

Each arch rib is 4 ft. thick throughout and varies in depth from 4 ft. 8 ins. at the spring to 6 ft. 2 ins. at the crown. It is reinforced near both upper and lower surfaces with six 1¼-in. corrugated bars, but not at all transversely or vertically. Rising from the ribs and acting both as transverse braces between them and as supports to the floor system are eight cross beams or arches. The two nearest the crown are straight beams running into the rigs and forming an integral connection thereto, the next two rest on the top of the rib, with curved lower planes running down into the rib, while the four nearest the abutment are a part of a system formed by columns resting on the ribs and carrying the curved bottom beams at their tops. The appearance of these floor beams from underneath is shown in Fig. 13. From the pier to the second cross beam from the crown, the spandrel wall is hollow, formed by two 8-in. reinforced walls resting on the outside and inside of the arch ribs and not carrying any load. From this second beam to the crown, the arch ribs continue in full width to the coping. This difference in section does not appear on the outside spandrel wall, which to the observer is of the same section across the bridge.

The transverse beams are reinforced as beams, with additional precautionary reinforcement running down into the curved lower portion. As shown in Section XY, Fig. 5, the inner face of the spandrel walls fit into the beams, but the outer face passes around their ends. The columns upon which they rest are reinforced with eight 1-in. straight rods, which extend down into the concrete of the arch ribs. Dowels are also provided in the arch ribs which serve both to bond the ribs to the spandrel walls and as connecting rods to the reinforcement in the spandrels.

The roadway is formed by four concrete-encased 20-in., 72-lb. I-beams, spanning the cross beams, and spaced in two groups each on 5-ft. centers so as to provide bases for the tracks of the railway. The space between the tracks is left open, but the remaining space is bridged by a 5-in. reinforced-concrete slab sloping down to drain scuppers as shown in the figures. Over the spandrel walls another slab is built to form an emergency footwalk, and at the extreme outside there is a coping beam carrying the balustrade. Under these sidewalk slabs is an open space for the use of cable conduits. The tracks of the railway are to be laid on wooden ties laid on the concrete-encased I-beams.

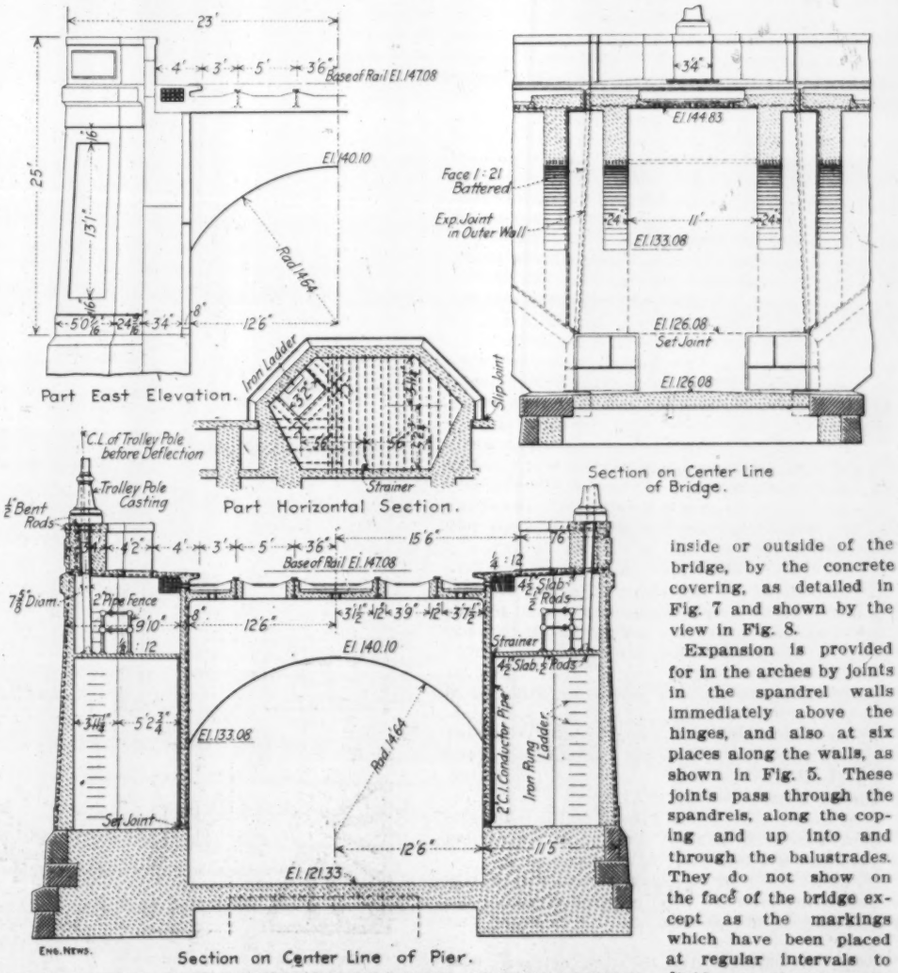
The details of the reinforcement of the concrete casing around these I-beams is shown on Fig. 6. It consists of wire-cloth attached to rods wedged into holes punched in the webs of the I-beams and tied to the reinforcement of the intervening floor slab areas. On this same figure is also shown the details of the balustrade, which is cast in place on the copings.

The piers above the solid floor spoken of above, which was completed in the foundation portion of the work, are also of the same general hollow construction as the arches. As shown in Fig. 4, the side sections, solid to the elevation of the granite facing, are carried up to the final elevation as hollow structures, the faces formed by their reinforced-concrete walls. These openings are roofed over near the top and provided with manholes permitting ingress to the openings, which may be used as storage places. The roadway across the piers is carried on two transverse arches similar to those in the arch span proper. The outer faces of the piers are in semi-octagonal section, protruding beyond the plane of the spandrel walls to the face of the dam.

HINGES.—As the piers were completed some time before the arches were commenced it was thought best to provide some sort of a skewback other than the ordinary integral connection between arch rib and pier, so the novel expedient of a two-hinged concrete arch was adopted. The main elevation of the arch in Fig. 5 shows the hinge at the spring as it was assembled and Fig. 7 gives its details. The pier portion of the hinge is a cast-iron casting arranged so as to distribute the load through a pin to the vertical and horizontal faces of the pier indent and the rib portion is a similarly shaped cast-steel casting with an interlocking jaw through which the drop forged pins pass.

In construction the lower section was first set on the shelf provided for that purpose and the upper portion connected to it by the pin and also by the ¾-in. adjusting bolts shown. The skewback was then concreted up to the skewback line shown, which is at right angles to the line of thrust from the arch. The forms for the arch rib were then placed, but before concreting the ribs a sheet of zinc was laid across the skewback, both above and below the pin, tapering from a sharp edge at the pin to about ⅜ in. at the top and bottom, and against these sheets the concreting of the arch ribs was made. This precaution was taken in order to provide some leeway for hinge movement both during the erection of the bridge and afterward. It should be noted that the hinge is completely screened from view, either from the inside or outside of the bridge, by the concrete covering, as detailed in Fig. 7 and shown by the view in Fig. 8.

Expansion is provided for in the arches by joints in the spandrel walls immediately above the hinges, and also at six places along the walls, as shown in Fig. 5. These joints pass through the spandrels, along the coping and up into and through the balustrades. They do not show on the face of the bridge except as the markings which have been placed at regular intervals to divide up the face for architectural purposes.



ENG. NEWS.

FIG. 4. DETAILS OF THE UPPER PART OF PIERS, IN REGULAR PIERS NOS. 2, 5, 6, 7, 8 AND 11.

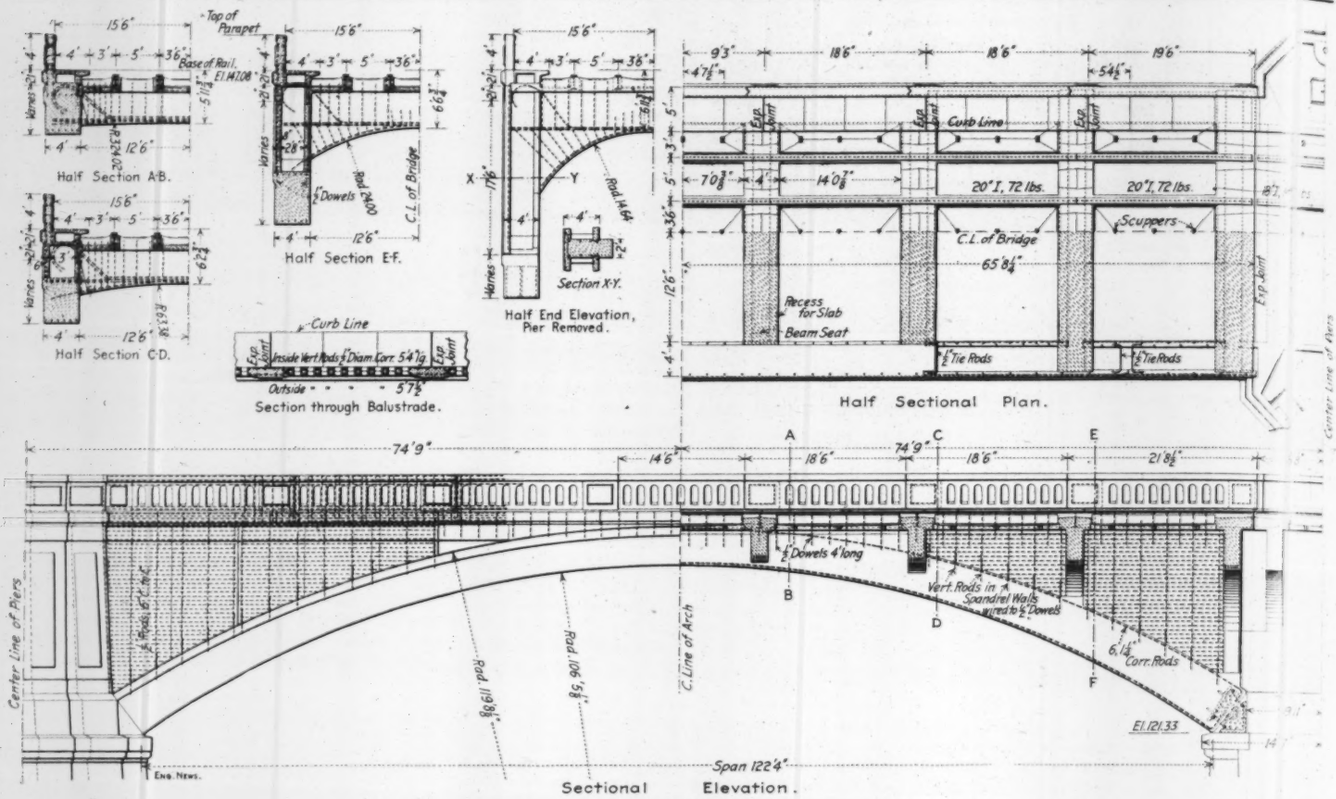


FIG. 5. DETAILS OF 122 FT. 4 IN. ARCHES.

Plate-Girder Span.

The plate-girder span at the west end of the bridge is shown in Fig. 9. It consists of four main plate-girders and two lattice-girders of steel, each completely encased in concrete and carrying a solid floor system of reinforced concrete with a ballasted roadway. The girders are braced together with steel latticings which are not individually encased in concrete, but which are screened from view and the weather by concrete slabs spanning the bottom flanges of the girders.

The steel work of the main girders is of standard design, four plate-girders, each 75 ft. 2 ins. c. to c. of bearings and 60 ins. deep, with a sliding joint at each end. It consists merely of a plate bolted to the concrete, and provided with longitudinal lugs to prevent sideways motion, while a plate riveted to the bottom of the bottom angles limits the longitudinal movement of the girders. These plates are mounted on a lower and forward part of the pier, the main upper section of which is some 3 ft. farther back. The space is spanned by a longitudinal bracket, the top of which nearly reaches to a transverse concrete girder across the piers. The open expansion joint is here spanned by a flat plate.

In addition to the four main plate girders, there are two shallow lattice girders, forming the outside bearing stringers for the outer curved screening slabs and the two railing lattice girders, which act as beams across the entire span.

The concrete casing around the individual members, reinforced wtih wire cloth attached to rods tied into the girders and the floor slab, which is solid across the bridge, is also reinforced with wire cloth. These and the outside curved screening slab are cast in place on the bridge, but the lower screening slabs, small arches spanning between the lower flanges of the main girders, were cast in short sections in the casting yard and slid into place after they had set.

From the end of this span, beyond Pier 13, the line is carried on a steel elevated structure descending to the surface about a thousand feet away.

The drawbridge over the lock entrance near the Boston side of the bridge is to be of the Strauss bascule type, lifting from one side, although as shown in the general elevation in Fig. 1, it is to be designed with a curved lower chord to resemble an arch and to be in keeping with the remainder of the structure. Work upon it has not been started as yet.

Construction.

As stated before, the piers and the superstructure of the bridge were practically two separate pieces of work. The construction of the bridge proper is all being carried on from the Cambridge end, where the company has a storage yard and where it was more convenient to locate the concrete plant. The erection has, therefore, progressed from the spans at that end of the bridge toward Boston, concrete being carried out from the mixing plant on a trestle forming part of

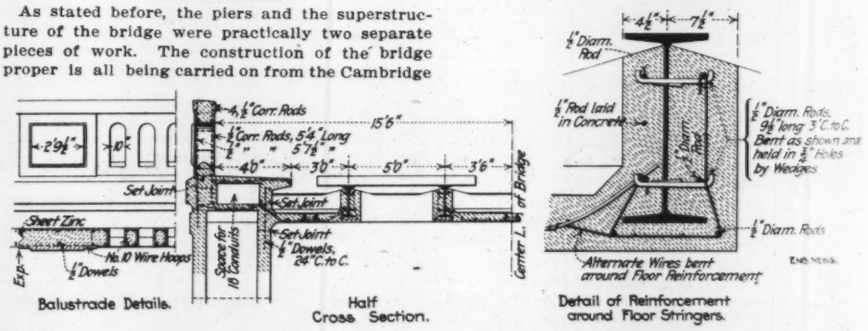


FIG. 6. TYPICAL DETAIL OF FLOOR CONSTRUCTION.

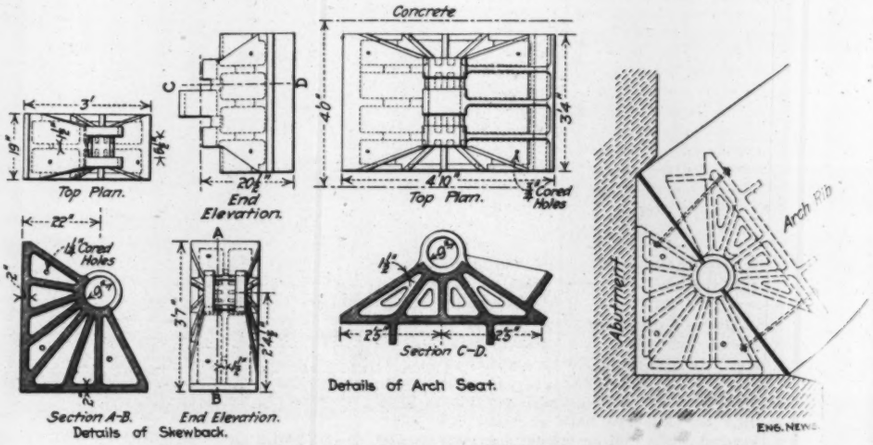
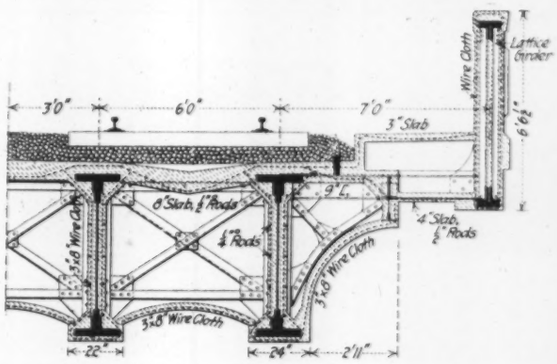


FIG. 7. DETAILS OF ARCH HINGES.

FIG. 8. VIEW OF ARCH SKEWBACK SHOWING HINGE AND METHOD OF SURFACE TREATMENT.



Typical Cross Section of Span.

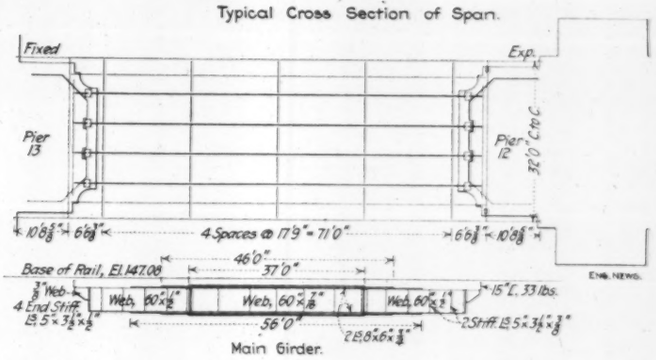


FIG. 9. DETAILS OF PLATE GIRDER SPAN AT CAMBRIDGE END OF BRIDGE.

the falsework for the arches to the draw span opening, over which it was swung by derrick boats to a similar trestle for the two spans on the Boston side of the draw.

Fig. 10 shows the details of the centering on which the bridge was erected. First, eight piles were driven clear across the bridge, except in the draw-span opening, spaced about 9 ft. longitudinally and 6 ft. 6 ins. transversely. On these piles, the three bents shown in the section were erected, the outer two for the arch ribs and the inner one for the erecting track. Upon these centers the erection is carried on in the following order: (1) arch ribs; (2) cross arches; (3) stringer I-beams; (4) spandrel walls; (5) coping and I-beam casing; (6) pier sides, and (7) balustrade. When the construction of the side walls has progressed far enough and the arch ribs have acquired sufficient set, the centers are removed and the ties and supports for the construction track are allowed to rest on the I-beams and the centers are moved ahead to the next arch which is to be built. Thus in Fig. 2 the arches in the background have been practically completed and the centering has been removed to those in the foreground, the track meanwhile resting on the completed transverse arches.

The concrete mixing plant is opposite Pier 11, on the Cambridge side, alongside the yards of the Boston & Maine Ry., so that tracks can be run in loaded with the various materials. The layout is shown in Fig. 12. Stone, cement and sand is kept in separate storages in the mixing plant and dump successively into the car which runs out over a hopper dumping into either of two mixers. These mixers discharge each into a self-dumping bucket which is lifted through a tower up to another hopper discharging into hopper cars running on the narrow-gage tracks on the falsework, which cars carry the concrete to its required place, discharging through side chutes, placed as may be seen in the view in Fig. 11.

All of the machinery of the mixing and transporting plant is electric driven, through the power cables of the Boston Elevated Ry. The mixers are driven by motors, located as shown in Fig. 12, and the cars are hauled by electric locomotives, through trolleys. One of these locomotives and its cars are shown in Fig. 14.

Several kinds of surface finish are provided. The arch rib is composed of a 2-in. maximum stone mixture and is dressed with a fine crandall while the spandrel walls and the pier sections are of larger aggregate treated with a wide point crandall, in the hands of workmen, which gives a much rougher surface. The arch rib hand between the two is bush-hammered with a pneumatic hammer, giving the effect shown in Fig. 8. The upper works are to be dressed with a bush hammer similar to the arch rib. As the aggregate used is a crushed granite the finish fits in very well with the granite cut stone of the piers. The concrete work is remarkably well done, close grained and compact so that the surfaces are fine and the general effect most artistic.

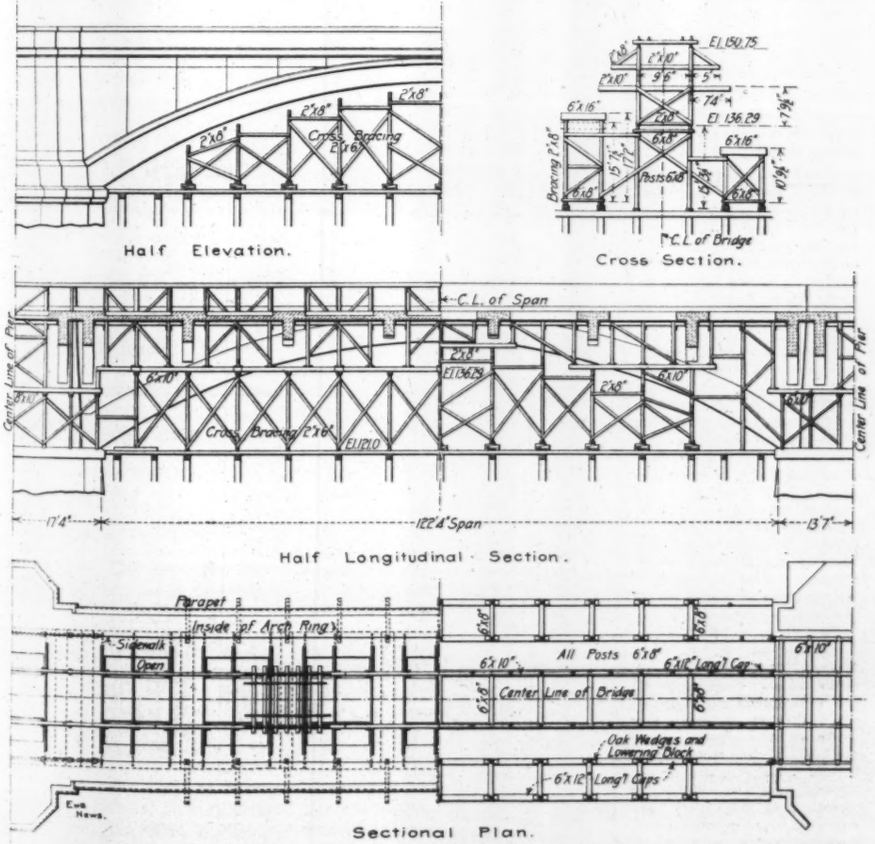


FIG. 10. TYPICAL CENTERING FOR ERECTION OF CHARLES RIVER BRIDGE.

Design.

The loads used in calculating the stresses in the various portions of the bridge are as follows:

Live load on train of 50 ton cars, each 46 ft. over all; c. to c. of trucks, 25 ft. 6 ins.; c. to c. of axles 5 ft. 6 ins; uniformly distributed live load on sidewalk 100 lbs. per sq. ft. The impact from the train load was derived from the following expression: $\frac{300}{380+L}$, L being the loaded length of track producing maximum stress in any member.

The steel stringers were designed for an extreme fiber stress of 16,000 lbs. per sq. in. All reinforced-concrete floor beams, stringers and slabs were calculated in accordance with the

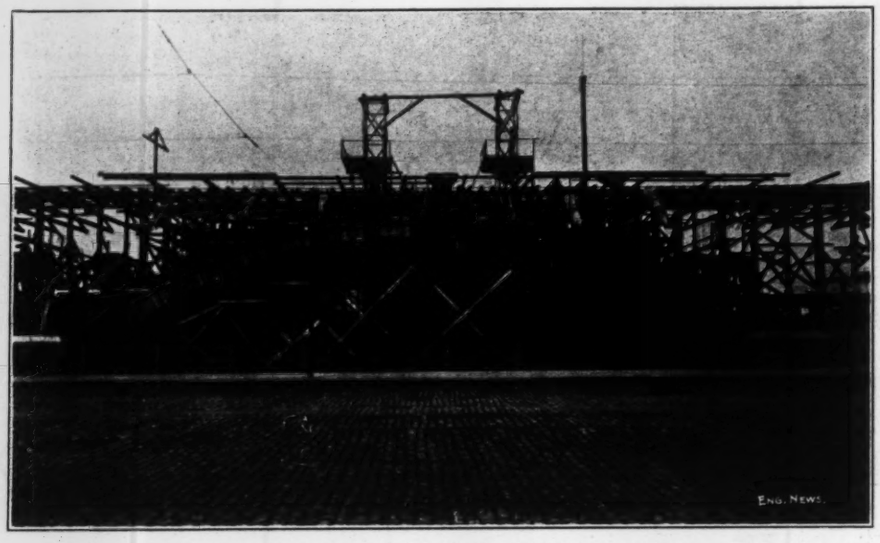


FIG. 11. VIEW OF ONE OF THE ARCHES DURING CONSTRUCTION, SHOWING METHOD OF DEPOSITING CONCRETE.

rules in Progress Report of Special Committee on Concrete and Reinforced Concrete of the American Society of Civil Engineers, dated 1910. The arch ribs were calculated for full and partial live load, together with a rise and fall of temperature of 30° F. above and below normal. The maximum compressive stress, on the concrete, including the stress from temperature, was allowed to run up to 900 lbs. per sq. in., or without the temperature stress, 700 lbs. per sq. in. The steel in the arch ribs was stressed to about 13,500 lbs. per sq. in. in compression. There was practically no tensile stress in the steel in the arch ribs.

The bearing on the stone masonry under and back of the skew back castings amounted to about 800 lbs. per sq. in.

Personnel.

The bridge was designed under the direction of Mr. George A. Kimball, Chief Engineer, and Mr. C. T. Fernald, First Asst. Engineer, of the Boston Elevated Ry., with Mr. J. R. Worcester, as Consulting Engineer in immediate charge of design. The construction is being carried by the Boston Elevated Ry., without the aid of a main contractor and Mr. C. W. Rogers is assistant engineer in charge of construction under Mr. Fernald and Mr. Kimball. The architectural design was in charge of Mr. Robert S. Peabody and was passed upon by a board of architects. Mr. Guy Lowell was the consulting architect to the Charles River Basin Commission.

A NEW USE FOR THE AUTOMOBILE has been found on the Upper Mississippi River. Here an owner of a "Case" car also owned a houseboat, and he devised a scheme of running a motor-car onto the houseboat, jacking up the rear wheels, attaching skeleton sprocket wheels to them and then connecting with a paddle wheel thrown over the rear of the boat. In this way ample power for propulsion was secured. It is claimed that only a few moments are necessary to remove the attachments or put them on, so that a power boat or a land vehicle is available at will.

PRIVATE OWNERSHIP OF WATER in California is made impossible by an amendment to the Civil Code of the State adopted by the legislature recently. Under this amendment, "all water, or the use of water within the State of California, is the property of the people of the State of California."

A law was also enacted to prevent water rights from being held out of use, one section reading as follows:

All water or the use of water which has been heretofore appropriated and which has not been put, or which has ceased to be put to some useful or beneficial purpose, or which is not now in process of being put to some useful or beneficial purpose with due diligence in proportion to the magnitude of the work necessary properly to utilize for the purpose of such appropriation such water or such use of water, is hereby declared to be unappropriated.

Annual Meeting of the American Society fo Testing Materials.

[Concluded from page 35, Eng News, July 7, 1911.]

In our last issue we reviewed the newly formulated specifications and the active investigative work of technical committees of the American Society for Testing Materials. Before proceeding to a survey of the technical papers presented at the meeting, there are a few items of interest regarding new committee work to be undertaken.

New Committee Work.

WHITE PAINT TESTS.—The Paint Committee (D-1) has projected as an extension of its current investigations a very comprehensive exposure test of white paints. An extract from the report of the sub-committee (chairman, Mr. P. H. Walker, Chief Chemist, Contracts Laboratory, Bureau of Chemistry, Washington, D. C.) gives an outline of the work as planned and already started:

It was decided in conducting these tests to limit them strictly to white paints, not to use any tints. The paints are to be applied on both sides of yellow poplar panels, 8 × 1 × 36 ins. Three of these single pieces are to be clamped together, forming a temporary surface 24 × 36 ins. for the application of the paint. The paint is to be applied at a definite spreading rate; three coats with at least seven days' time between coats for drying. Two sets of these panels, each consisting of three pieces painted on both sides, are to be used for each test. These panels are to be exposed in a fence or rack to be constructed as follows: Posts of locust or red cedar, 10 ft. 10½ ins. long by approximately 6 ins. in diameter planted in rough concrete 2½ ft. deep, 10 ft. 6 ins. in the clear between the posts, are to be connected by three lines of 2 × 4-in. yellow-pine stringers. The top stringers are to be spiked to the top of the posts; the middle and bottom stringers are to be notched in and spiked with a clearance of 36½ ins. Two strips of 1-in. quarter-round molding are to be fastened with brass screws to the upper surface of the bottom stringers, the upper and lower surface of the middle and the lower surface of the top stringers with a clearance of 1 in. between parallel lines of molding. The whole frame is to be painted with three coats of red oxide of iron ground in linseed oil. The panels after having been painted and dried under cover are to be placed in the rack by removing one of the strips of molding, inserting the panels and replacing the molding strip. This fence is to be located so as to run north and south.

The mixtures of pigments are designed on the volume basis; that is, the mixtures, which are directly comparable, contain the same relative volumes of different pigments. The pigments are to be mixed with raw oil in which is to be added a known quantity of lead and manganese as linonates; sufficient oil is to be used to give a standard viscosity.

The Committee has received donations of a sufficient quantity of the following pigments:

White lead, Dutch process; white lead, Carter's process; white lead, Acme White Lead Co.; zinc oxide, French process; zinc oxide, American process; sublimed lead; zinc lead white; silica; asbestine; china clay; calcium carbonate; calcium sulphate; barytes.

The first seven of these are to be tested in single-pigment paints. Besides these, 35 binary, 70 ternary and 6 quaternary mixtures of pigments will be tested. Linseed oil for use as vehicle has been donated, and Prof. A. Rogers (Pratt Institute, Brooklyn, N. Y.) will grind the paints. It is expected that a site for the exposure fence will be found in the neighborhood of Washington, probably at the experimental farm of the Department of Agriculture at Arlington, Va. The wooden panels will be prepared by the Pennsylvania R. R., and they will be painted by the Baltimore & Ohio R. R.

SOFT COPPER WIRE.—Committee B-1, on Hard-drawn Copper Wire, has considered the question whether its work does not also involve naturally a study of soft copper wire, and reached an affirmative conclusion. Neither the society authorities nor the annual meeting objected to this broadening out, so that the committee is likely to work on soft wire during the coming year.

NEW COMMITTEES.—Three new technical committees were established by the Executive Committee during the past year: A-2, on Standard Specifications for Wrought-Iron, temporary chairman Mr. J. Allen Colby (Inspecting Engineer, Philadelphia, Pa.); C-6, on Standard Tests and Specifications for Drain Tile, temporary chairman Prof. A. Marston (Iowa State College, Ames, Iowa); and E-3, on Definition of the Term "Modulus of Elasticity" in its Application to

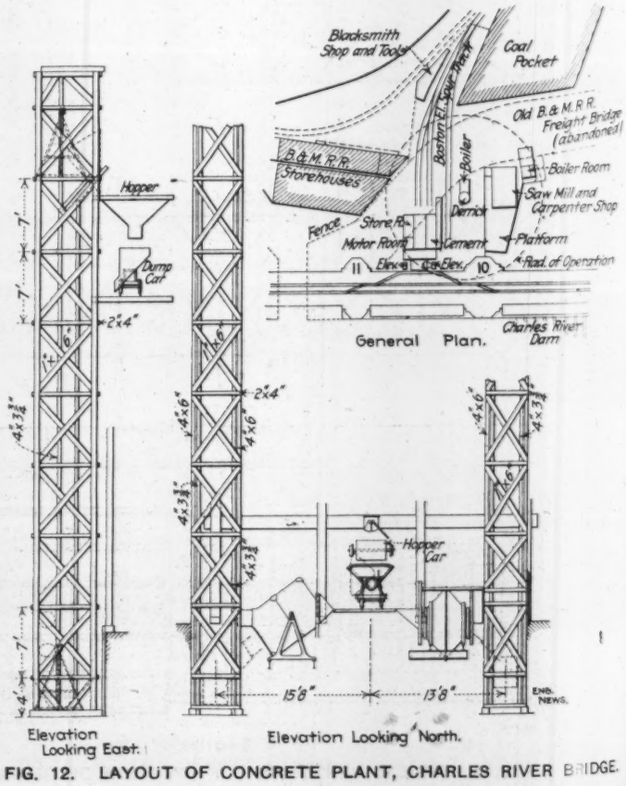


FIG. 12. LAYOUT OF CONCRETE PLANT, CHARLES RIVER BRIDGE.

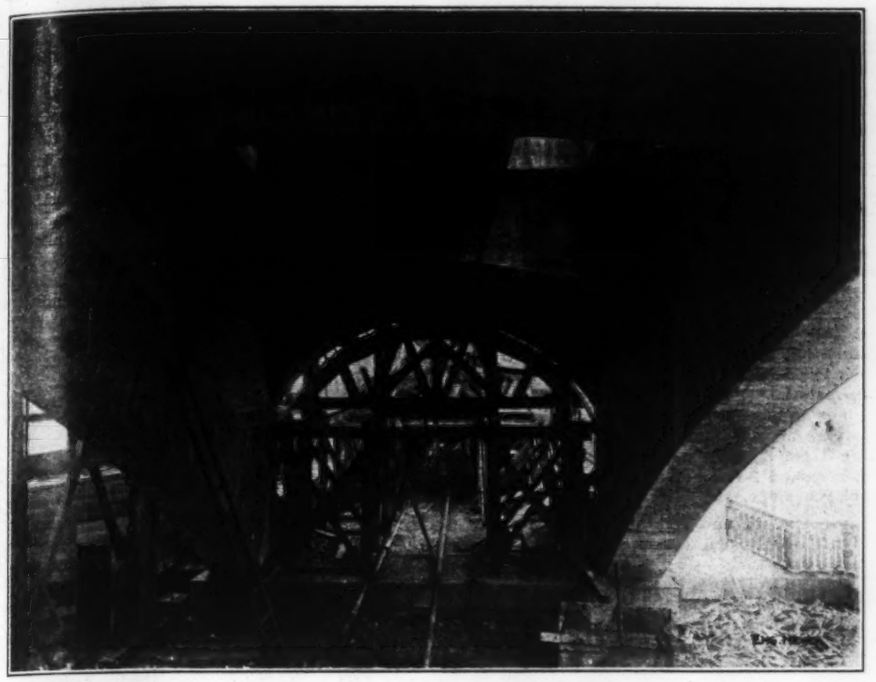


FIG. 13. VIEW OF UNDER PART OF ARCH AT PIER SHOWING LIGHT CONSTRUCTION.

Materials, Including Non-Ferrous Metals and Their Combinations, temporary chairman Mr. Leonard Waldo (Consulting Engineer, New York City).

The Committee on Drain Tile will give first attention to standard test methods; specifications for the material are to be considered later. This committee is wholly independent of the Sewer Pipe Committee, although the materials are similar. The paper on Tests of Sewer Pipe and Drain Tile, presented by Prof. Marston at the meeting of the society, noted farther on, is not to be considered as part of the committee work.

New Testing Methods and Results.

Under the title "Measured Strains in Engineering Structures," Mr. J. E. Howard (Bureau of Standards, Washington, D. C.) gave an illustrated lecture showing the method he has developed for measuring load compressions and elongations of structural members by permanent gage-marks and a specially well designed micrometer gage, as first described in Engineering News of March 23, 1911 (p. 352). He showed also some results of the strain measurements on members of the great Beaver Bridge (cantilever) over the Ohio River, the Bankers' Trust Building in New York City, and two old boilers in Providence, R. I., exemplifying the high precision of this micrometer-gage method and the diversity of application open to it.

Mr. Robert Job (Milton Hersey Co., Ltd., Montreal, Can.) presented the results of a study of the formation of cinder-like accretions on tube-sheets of locomotives, under the title "Flue-sheet Cinders, Cause of Formation in Locomotives." By a combination of chemical analyses of the troublesome flue-sheet accretions called cinders, and of fuel and ash, with physical study of the cinder formation, he showed that such accretions are due to the use of fuel having an ash rich in iron. Ash of this character is readily fusible, and when such ash dust is sucked up against the tube-sheet by the draft it adheres to rough places of the tube-sheet and fuses into a growing excrescence. On account of local heating by dissociated water, wet coal favors cindering, and greater liability to accretions is found in simple engines on account of the stronger draft as compared with compounds. On the other hand, the cinder formation is avoided by the use of white-ash coal, or of coal whose ash has an iron content below 1.5%. Mr. M. H. Wickhorst (C., B. & Q. R. R., Aurora, Ill.) remarked that the condition of the flue-sheet is also of influence in cinder formation, as a sheet having rough projections or tending to develop blisters or roughnesses, will favor the cinder accretions.

Detecting "Bloom" in Oil by Fluorescence.

The bluish or milky appearance of mineral and resin oils, known as "bloom," often gives a means for detecting the adulteration of linseed oil with such oils. Processes have been developed by which oils are "debloomed," and since the analysis of linseed oil is as yet far from being exact enough to detect all adulterations, the debloomed oils are convenient adulterants. Mr. A. E. Outerbridge, Jr., (chemist, Philadelphia, Pa.), observed that oils which display bloom also fluoresce very strongly in ultraviolet light. Crude oil, kerosene, resin oil, etc. (but not gasoline), display an intense blue or greenish color when viewed by reflected light containing ultraviolet rays. Linseed oil does not fluoresce. The ordinary enclosed arc lamp gives off ultraviolet rays, and it may therefore be used as a means for detecting fluorescent oils. By making up comparison standards of linseed oil containing progressively increasing amounts of fluorescent oil, a scale is had with which any suspected sample may be compared as to depth of fluorescence. The method is very sensitive and accurate.

Mr. Outerbridge described his method in a paper, "A Novel Method of Detecting Resin Oil and Mineral Oil in Other Oils." The presentation of this paper resolved itself into a complete and striking demonstration of the method; an enclosed arc lamp had been rigged over a table in the meeting room, and in its light Mr. Outerbridge showed several dozens of oil samples, pure and mixed, and several of his sets of comparison standard mixtures.

Hardness Tests.

The subject of tests for hardness was discussed in several papers. Mr. Bradley Stoughton and Prof. J. S. Macgregor had a paper on "Hardness Tests," and Mr. Albert F. Shore one on "The Property of Hardness in Metals and Materials," while Mr. R. P. Devries presented two papers, "Hardness in Its Relation to Other Physical Properties," and "A Comparison of Five Methods of Hardness Measurement.' All these papers had bearing on the question, Which of the proposed methods of measuring hardness gives the most useful indication? Mr. Shore's paper dealt with the use of the Shore "scleroscope," and showed a set of test curves from which might be concluded an erratic behavior of the Brinell ball test as compared with greater uniformity in the Shore test. He dwelt on the cheapness and wide applicability of the scleroscope test. The paper of Stoughton and Macgregor, in so far as it gave data for comparison, indicated that the results of the two methods harmonized fairly well.

Mr. Devries' paper, on the other hand, showed the results of several large sets of tests, in which the different tests (Brinell ball, Ludwik cone, scleroscope) gave widely divergent results. The Keep drilling test and the Ballantine lead-disk test were also discussed in the paper. The scleroscope was found to show high hardness for tough metals. A certain similiarity of action was obtained in the ball and the cone pressure tests, i. e., plotting the several results for a large number of different metal samples, on an arbitrary abscissa scale, the curves of the two tests had similar shape. In using the scleroscope, three different modifications of hammer were tried; they assigned quite different order of hardness in testing a range of several dozen different samples (steels and bronzes.) The attempt was made to coordinate hardness with tensile strength and elastic limit, by making these tests and also a Brinell and a scleroscope test for each of 30 different steels. Plotting the results in the order of decreasing ultimate tensile strength, it was found that the curve of Brinell values exhibited

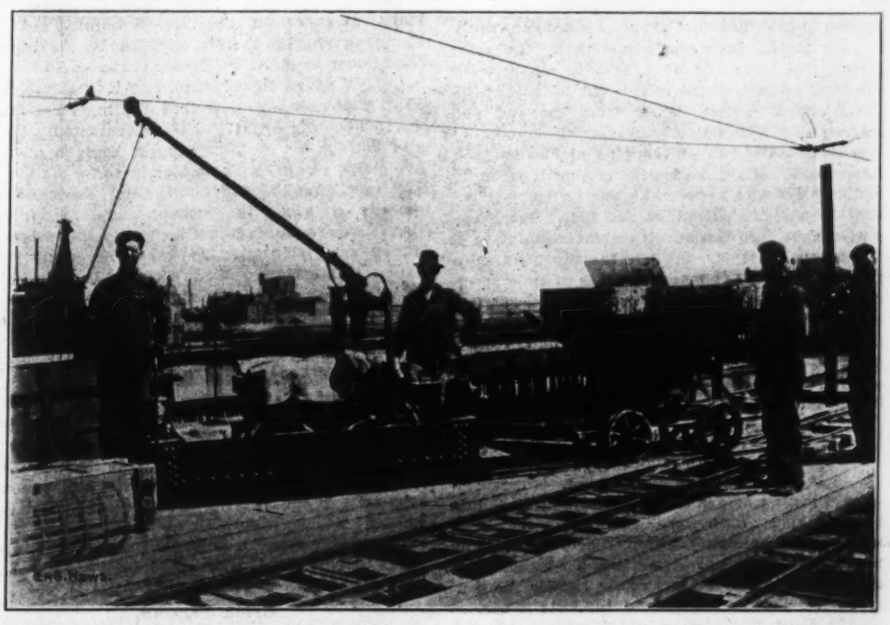


FIG. 14. VIEW OF ELECTRIC LOCOMOTIVE AND CONCRETE CARS, CHARLES RIVER BRIDGE.

a rather general parallelism with the ultimate strength curve, but none whatever with the elastic limit curve. The scleroscope values showed no parallelism with either.

Mr. Leonard Waldo (Consulting Engineer, New York City) in discussion described an instrument which he had used successfully for measuring hardness. It employs 1/10-lb. weight suspended by silk fibre held in a trigger so that it can be released; its fall is 1 ft. The lower surface of the weight is fitted with a small needle projection having a conical point. A pocket-lens micrometer enables the diameter of the indentation produced by this needle to be measured quite accurately.

The papers and discussion made evident a great amount of interest in hardness testing, but experiences and opinions differ very widely on the subject of best method of testing, meaning of results, etc. The subject was to be touched also by Prof. W. K. Hatt (Purdue University, Lafayette, Ind.) in a paper, "The Brinell Ball Test Applied to Wood," but the paper was not at hand and was taken as read.

TESTS OF CASE-HARDENED GEARS.—Several forged steel pinions, case-hardened by a new secret method, were tested by Mr. Bradley Stoughton and Prof. J. S. Macgregor (Columbia University, New York City), who described the work in a paper. Hardness test made at the surface and at different depths from the surface by the Brinell, Shore and Turner methods showed concordant differences in hardness, the center being softest. Analyses showed the carbon to be 0.21% in the center and 1.0% at the surface. It was then desired to know the breaking strength of the teeth, and tests were made after cutting away all but a narrow slice of tooth, load being applied normal to the tooth face at the pitch line. In a pinion of uniform 0.40% carbon the tooth broke off short, while in the case-hardened pinions the tooth deformed without breaking, though the skin cracked off; the maximum loads were about equal. The Fremont impact test also gave about equal results.

Mr. Geo. L. Fowler (New York City) in discussion contributed some observations on shrinkage and press-fit stresses in electric-railway pinions. Tangential stresses of 57,000 lbs. per sq. in. were observed in pinions driven on, but by shrinking on by boiling the stress was only 29,000 lbs. In these gears the working stress was about 19,000 lbs. per sq. in. at the root of the tooth; the elastic limit of the material was 70,000 lbs.

A Shop Test for Tube Welds.

Mr. F. N. Speller (National Tube Co., Pittsburg, Pa.), in a paper, "Recent Developments in Testing Boiler Tubes," described a highly useful shop test recently developed to detect poorly welded tubes. It is performed by a machine having a pair of squeezing jaws and just above this a downwardly moving punch, both set in motion by the same lever. The crop end of a tube is set between the jaws as soon as the tube is cut to length; the jaws grip it a few inches from the end and squeeze it flat, and simultaneously the punch descends into the end of the pipe and expands it into a wide collar. Bad welding shows promptly under this severe treatment. The test is over before the pipe has passed on, and thus a suspicious pipe can be thrown out with great certainty.

This test, said Mr. Speller, has given valuable pointers on some common features of tube specifications—the sulphur limit, for example. Out of a large lot of tubes tested, the average loss was 20% for those tubes which ranged around 0.027% sulphur, and only 14% for those which ranged around 0.045%; this tends to show that the 0.03% limitation may not be necessary.

Two New Testing Machines.

The firm of Tinius Olsen & Co., Philadelphia, Pa., has designed and built a new transverse-impact testing machine, and a new static-bending test machine. Both were described at the meeting by Mr. Thorsten Y. Olsen. The static bending machine is a convenient autographic machine for short specimens. A hand screw applies the central load, and one of the end supports is carried on the short arm of a weighted bell-crank lever, whose arc of swing thus measures the load. A recording cylinder is turned in proportion to the deflection of the test-bar, and a pencil is moved along the cylinder by a lever moved by a cord connected to the load-measuring pendulum.

The impact test machine has a swinging pendulum hammer, which is raised by a hand-wheel and released by a trigger. It is recessed to straddle a narrow vise, located below the pivot. A test specimen set in the vise projects up and is struck by the hammer head. The energy left in the pendulum carries it up an arc measured by a drag pointer indicating on a graduated arc, so that the consumed energy of rupture can be determined.

Discussion of impact tests led Mr. A. E. Outerbridge, Jr., to remark that in a test where a 15-in. fall would ordinarily produce fracture, he found that by starting at 6-in. fall and increasing inch by inch, a 25-in. fall was required to break the material. This was in cast iron. He referred also as an analogous phenomenon to the strength-increase of cast-iron test-bars produced by putting them through the tumbling-barrel, which phenomenon he discovered and announced several years ago.

Sewer and Drain Pipe Tests.

Prof. A. Marston (Iowa State College, Ames, Iowa) presented a paper, "Standard Tests for Drain Tile and Sewer Pipe," describing test methods developed at Ames and subsequently adopted as standard by the Iowa Engineering Society and three other societies in the State. The paper gave much the same information as a paper of the same title, by Prof. Marston and Mr. A. O. Anderson, printed in Engineering News, March 2, 1911, page 258. The testing machine designed for making the crushing tests of the pipe was illustrated by Mr. Anderson in Engineering News, May 18, 1911, page 609.

Tables of test results were given in the present paper. They showed values of absorption from 4% to 14% for cement drain tile, and 2½% to 18½% for clay drain tile. The breaking strength of cement drains ranged from 500 to 2,000 lbs. per lin. ft. in the small sizes, and from 1,000 to 3,000 lbs. per lin. ft. in the large sizes; the corresponding moduli of rupture were 400 to 2,000 in the small sizes, and 300 to 600 lbs. per sq. in. in the large sizes. Clay pipes ranged rather higher, especially the sewer pipe, the latter developing moduli of rupture ranging from 900 to 2,500 lbs. per sq. in.

The chief feature of the Marston crushing test is the use of 90° sand cushions at top and bottom. It is claimed that this virtually reproduces the condition of loading to which the pipe is exposed in service. To compute earth loads in trenches, suitable analysis and curves are given in the paper, the analysis being of the same character as for grain-bin pressure. In discussion, the view was expressed that there is nothing gained by trying to make the test approximate the trench conditions; Prof. A. N. Talbot (Urbana, Ill.) and Mr. C. W. Boynton (Chicago, Ill.) took this view. Prof. Talbot briefly described the machine built at Illinois, where the load is concentrated at top and bottom, the bottom support being made of two strips separated by an inch or so for stability. Mr. M. Schuyler (St. Louis, Mo.) described a method by which the amount and direction of the earth pressure against a pipe could be determined experimentally; as gages he would use closed elastic tubes filled with liquid and held between pressure plates, the pressure developed by the liquid being a measure of the pressure on the plates.

Prof. Edward Orton, Jr. (Ohio State University, Columbus, O.) discussed absorption, an absorption test being included in Prof. Marston's standard schedule. In clayworking it is found that minimum absorption is not necessarily a gage of the best burning, as clays differ both in point of minimum porosity and in point of best burning, and for a given clay the two points may not coincide. To use absorption as a gage of quality in any other respect, however, is erroneous, and leads to unfair comparisons between cement and clay pipe.

Brick Testing.

Prof. Edward Orton, Jr., (Columbus, Ohio), and Mr. M. W. Blair (Indianapolis, Ind.), gave an excellent presentation of a purely empirical study, by describing the experiments which led to formulating the new rattler test adopted by the National Paving Brick Manufacturers' Association last February. The rattler and test procedure were fully described in Engineering News of March 16, 1911, page 334. Series of tests in bricks of the same lots were run by the two investigators in separate laboratories, and the discrepancies and irregularities were investigated until one factor after another had been examined for its effect on uniformity. The adoption of spherical shot, an important feature of the new test, was not possible until the influence of varying hardness of iron had been eliminated, and the effect of slight differences in rattler speed detected. Regularity of result, of course, was the principal thing sought. Incidentally, spherical shot is less severe on the brick than cubical shot, giving on the average 2% less loss, and new staves give 2 to 3% less loss than old distorted staves.

SPECIFIC GRAVITY, ABSORPTION AND PERMEABILITY OF BUILDING BRICK.—Useful data toward a fuller knowledge of brick were contained in a paper, "Further Experiments on the Absorption, Porosity and Specific Gravity of Building Brick," by Messrs. D. E. Douty and L. L. Beebe (Bureau of Standards, Washington, D. C.). A short abstract of the tests and results will be given later.

Paint Tests.

Comparative exposure tests of paints were started on a large scale (as to number of test samples, but a very small scale as to size of test pieces) a few years ago by Westinghouse, Church, Kerr & Co. Mr. C. M. Chapman reported preliminary results last year (see Engineering News, Aug. 18, 1910, page 178). Further results were reported by him at the present meeting. Red lead, red lead primer and straight iron-oxide paints showed especially good results. The paper was strongly attacked by several, the claim being that its results are misleading and worthless because the test pieces are too small. Others, however, as strongly defended the methods employed by Mr. Chapman, and their arguments seemed to have the better of it.

Mr. H. A. Gardner (Washington, D. C.), in a paper entitled "The Practical Testing of Drying and Semi-drying Paint Oils," outlined a series of paint-vehicle tests being made by the Institute of Industrial Research for the Paint Manufacturers' Association. They are exposure tests, each vehicle or oil-mixture being ground to white paint with a standard white pigment and then painted on 2x3 ft. white-pine panel; 48 such panels form the test fence, erected in Washington, D. C. The exposure was begun a few months ago. The purpose of the tests is to find oils or mixtures which can be used in place of linseed oil, the price of the latter being now very high. There is some similarity between these tests and the new white-paint tests started by Committee D-1, noted earlier.

Corrosion of Iron and Steel.

An important group of papers dealt with corrosion, and the discussion was animated, not to say excited. While the subject is not exactly one of specific new test methods, we must class it under this head because corrosion investigations are so new and yet so unsettled that new methods and results are involved at all points.

Prof. W. H. Walker, of Massachusetts Institute of Technology (Boston), in "The Effect of Copper in Iron on the Acid Corrosion Test," showed by records of experiments that irons containing copper in small amounts give surprisingly excellent results in acid tests. For example, 0.16 to 0.20% copper added to open-hearth steel reduced its loss in acid by 30 to 40 times; and a similar result was obtained with a very pure steel (0.0% C.). Mr. A. S. Cushman (Institute of Industrial Research and American Rolling Mill Co.), who presided at the time, promptly attacked the figures and conclusions stated. He said that pure iron does not depend on copper for its resistance to sulphuric acid; just as good results can be shown without copper as with copper content. He claimed that Prof. Walker's figures are worthless because the oxygen content of the metal was not deter-

mined and said that acid-corrosion results depend very largely on the contained oxygen. Mr. J. A. Aupperle (American Rolling Mill Co., Middletown, O.) stated that many irons and steels had been tested by acid test in comparison with their own product, "American Ingot Iron"; one of the results was that very pure Swedish iron, which contained some copper, corroded much more rapidly than metal without copper. He further quoted numerous figures which tended to show that the oxygen content of the metal is responsible for high rate of acid corrosion.

Mr. C. M. Chapman (Westinghouse, Church, Kerr & Co., New York City), in a paper entitled "The Value of the Sulphuric Acid Corrosion Test," gave the results of two comparative tests, one by atmospheric corrosion, the other in acid, of a steel and an "improved iron." The results indicated that the acid comparison may be directly opposite to the comparison by atmospheric rusting. Mr. Cushman objected that the stated result is directly contrary to the showing of the Atlantic City panel tests, where, he claimed, bad tuberculation was developing on some steel panels. Mr. F. N. Speller (National Tube Co., Pittsburg, Pa.), however, remarked that except for two particular panels the charcoal and other iron panels showed up as well as those of "American Ingot Iron," if not better. Two Bessemer steel panels show tuberculation near the bottom. He believes that the sulphuric acid test is entirely misleading.

Prof. Chas. F. Burgess (University of Wisconsin, Madison, Wis.) made a plea for moderation of opinion until fuller study of the acid test is made. He has found quite opposite results, sets which tended to condemn the acid test and others which tended to show its value. The general trend of the results so far, he claims, is that materials which stand acid corrosion well are likely to resist other kinds of corrosion well. Mr. Cushman expressed his disbelief in a previous report of his own committee that condemned the acid test, and explained that he had signed the report (as chairman of the committee) only for the sake of harmony, believing that no method which might excite strong differences of opinion should be recommended by the Society. He said that he knows of no evidence against the acid test for corrosion resistance, but has yet an open mind on the subject.

Mr. A. W. Carpenter (New York Central & Hudson River R. R., New York City) presented by title a paper "Some Tests of the Comparative Rate of Corrosion of Metals Exposed in a Gaseous Atmosphere." The tests were exposure tests of plain, galvanized and lead-coated steel and "special iron," hung in a tunnel and in a roundhouse smoke-jack. The results again showed the erratic behavior of metals in corrosion tests, and in other respects also bear on the subject. We expect to give later an abstract of this paper, and of those of Prof. Walker and Mr. Chapman, the subject being one of very intense present interest.

Testing Bituminous Materials.

Three papers were read on the subject of physical tests for bitumens and substances of similar consistency.

Mr. Herbert Abraham (Standard Paint Co., Bound Brook, N. J.) described at two previous meetings several instruments which he has devised, (1) for testing the melting or softening point of bituminous substances, (2) for testing hardness or consistency, and (3) for determining the tensile strength. He has since improved these instruments and has carried out many tests with them, giving results in a paper "Improved Instruments for the Physical Testing of Bituminous Materials.—III."

A consistometer of another form has been designed by Mr. W. W. Crosby (Maryland Roads Commission, Baltimore, Md.). Like the Abraham instrument, it uses a needle with broad disk head, which is forced into the substance under test. The details of the construction and method of handling are quite different, however. The author's paper, "A New Consistometer for Use in Testing Bituminous Road Materials," showed drawings of the instrument, discussed its working, and gave some test results.

Mr. H. W. Fisher (Standard Underground Cable Co., Pittsburg, Pa.) described a very simple arrangement for getting the melting point of bituminous compounds, or rather two points, the "softening point," and the "drop point." The "softening point," is the temperature at which a plug of the compound, cast in a tapered hole in a steel block, will rise through mercury in which the block is submerged. The "drop point" is the temperature at which the compound runs or drips from a similar plug freely supported. The difference between the two points is an important characteristic; for example, waxes have the drop-point only a few degrees above the softening-point, while asphalts may have the drop-point 25° to 35° F. above the other. It is understood that a fixed rate of heating is to be employed. The method seems to have much promise for practical use.

OTHER PAPERS: MATERIALS AND QUALITIES OF MATERIALS.

A good part of the proceedings of the American Society for Testing Materials each year is devoted to reporting new tests of materials, and this part usually proves of wider interest than that dealing with new test methods. The volume of matter of this kind brought out at the meetings is evidence both of the importance of the subject and the steady growth of knowledge of materials. The papers reviewed below are chiefly such as give the results of new studies of materials; we regret that we cannot in most cases reproduce the results more fully. It may be remarked that subjects of cement and concrete engaged rather less interest at the 1911 meeting than at those of recent years, while an exceptional number of contributions on knowledge of steel was presented.

"American Ingot Iron."

A new open-hearth product of extremely low impurity content was described in Engineering News of Jan. 6, 1910, p. 6. A full review of the historical progress leading to this new commercial product, and new figures on its chemical composition and strength as produced in recent months, were given by Mr. A. S. Cushman (Washington, D. C.) in an address entitled "The Manufacture of Pure Irons in Open-hearth Furnaces." Condensing Mr. Cushman's figures, we obtain the tabulated figures below (Tables I. and II.). Wire drawn from the metal showed up to 10% lower ultimate strength than steel wire, and slightly lower elongation.

TABLE I.—CHEMICAL COMPOSITION OF "AMERICAN INGOT IRON."

(6 analyses.)

Element.	Min. %.	Max. %.	Average %.
Carbon	0.008	0.02	0.013
Sulphur	0.014	0.019	0.016
Phosphorus	0.001	0.005	0.003
Silicon	0.002	0.006	0.004
Manganese	trace	0.025	0.014
Copper	0.02	0.08	0.05
Aluminum	trace	0.013	0.008
Oxygen	0.016	0.024	0.020
Nitrogen	0.003	0.007	0.005

TABLE II.—MECHANICAL STRENGTH OF "AMERICAN INGOT IRON" IN PLATES AND SHEET-BARS.

(37 tests, on material made at various times in 1910 and 1911.)

	Min.	Max.	Average.
Area, sq. ins.*	0.346	1.97	0.968
Elastic limit, lbs. per sq. in.	21,900	38,700	28,300
Ultimate strength, lbs. per sq. in.	41,050	63,400	48,600
Elongation in 8 ins., %	17.2	38.8	28.5
Reduction of area, %	49.8	79.7	66.4

*Thickness of test-piece ranged from 0.230 to 0.989-in.

The marked variation in the figures which are summarized in our Table II. was accounted for by Mr. W. J. Beck (American Rolling Mill Co., Middletown, O.) as being due to different heat treatments of the material tested. Prof. H. M. Howe remarked that Mr. H. H. Campbell (Steelton, Pa.), who produced a low-impurity steel long ago, would doubtless be making it in large quantities to-day had he had Mr. Cushman and Prof. Walker to point out its value and enable him to sell it. Then President Howe opposed the attempted introduction of the term "ingot iron" as classification name, holding that "mild steel" is firmly established and the present satisfactory classification ought not be disturbed. Much discussion of this point ensued, but it brought no greater clearness of view; Mr. Cushman and his associates maintained that the metal is not steel and therefore needs a separate name. Incidentally Prof. Howe remarked that superoxidation of the bath is carried about as far in electric furnaces as in the American Rolling Mill Co.'s open-hearth furnaces; but while this superoxidation may produce a valuable new product the fact is not enough reason for a new name.

Studies of Steel.

Messrs. Robt. Job and M. L. Hersey (Montreal, Can.) presented a summary of extensive investigative work on steel locomotive-wheel tires. They discussed the various factors bearing on durability, as carbon content, grain size, etc., and dwelt particularly on the importance of fine structure. They have worked out a method of getting a micrographic test-piece from each tire without injuring it for use, by drilling a ¼-in. core ½-in. deep out of the edge of the tread, which gives a picture of the interior structure. They also advocate including in tire specifications a photomicrograph at 50 diameters magnification, to show the size of grain which will be accepted; this is to regulate the heat treatment, and the micrographic examination of the core-drilled test-piece may as further check be subjected to a hardness test. Prof. H. M. Howe made the further suggestion that specific gravity tests might be made on the drilled samples to determine degree of porosity, a matter not covered by other tests.

Under the title "Ductility in Rail Steel" Mr. P. H. Dudley (New York Central & Hudson River R. R., New York City) urged the importance of determining ductility before acceptance of rails, as a check on internal structure and wear-resistance.

A series of steels of varying carbon, with all other ingredients very low, was tested by Profs. C. R. Jones and C. W. Waggoner (West Virginia Univ., Morgantown), who reported their results under the title "A Study of the Elastic Properties of a Series of Iron-Carbon Alloys." The steels were specially made for test, by crucible process, and were annealed for two hours at 1,000° C. after being turned to finished test shape. On account of this treatment the elastic limit was about the same for all, 26,000 to 30,000 lbs. per sq. in., though the ultimate strengths ranged from 45,000 to 90,000 lbs. per sq. in. (carbon 0.60 to 1.37%). The elongation decreased to a low value at high carbon. The most remarkable feature of the results was that extremely variable moduli of elasticity appeared to be shown, from 22,000,000 to 28,000,000, with one value 40,500,000 and one for a different steel (0.06% C.) only 9,080,000! This fact aroused comment at the meeting, but it was discounted by the short length of the test-pieces (2 ins. gage-length). Others reported that they had always observed the conventional high degree of constancy of modulus of elasticity.

ACID VS. BASIC STEEL.—New matter on an old subject of discussion was furnished by Prof. Henry Fay (Mass. Inst. of Technology, Boston, Mass.) in a paper entitled "A Comparison of the Properties of an Acid and a Basic Open-hearth Steel of Similar Composition." Two steels of almost identical chemical composition were obtained, one having been made by the basic open-hearth process, the other by the acid open-hearth. They had C 0.42%, Mn 0.60%, P 0.009 to 0.027%, Si 0.033 to 0.067%, S 0.50 to 0.055%. The acid steel in tensile test showed about 15% higher ultimate strength (85,000—73,000), and elastic limit (43,000—37,000) than the basic, and fully as good ductility. This comparison, first obtained with samples tested as rolled, was practically duplicated by the tests on samples prepared by various heat treatments. The microstructure of the two sets of bars was quite similar, although in the bars as received the basic steel seemed to show more effects of mechanical working.

The question was raised whether the content of gases had been determined, and Mr. J. A. Aupperle (Middletown, O.) suggested that the hydrogen content of the acid steel might give a clue to the results of the tests. Prof. Fay replied that the tests were made some years ago,

and the results held for further opportunity to work on the same subject, which opportunity had not come, however. He believes that the analytical determination of oxygen, nitrogen and hydrogen would be of importance in connection with the results reported.

NICKEL-STEEL.—Further information about nickel-steel was given in a paper "A Study of the Heat Treatment of some Low-carbon Nickel-Steels" by Prof. Henry Fay and Mr. J. M. Bierer. Two steels, one of 3.14% nickel and one of 3.50% nickel, were studied by heating samples to various temperatures from 600° to 1,000° C. and cooling either in air, or in the furnace, or by oil quenching, the latter followed by annealing at 600° F. Tensile tests were made of all specimens. The plotted curves show that in both steels the oil-quenched specimens gave highest results in ultimate strength, elastic limit and elongation, while the furnace-cooled specimens were lowest. The best heating temperature for the 3.14% steel was 850° C., for the 3.50% steel 1,000° C. The microstructure was reported not essentially different from that of carbon steel.

A paper on the same subject, "On the Heat Treatment of a Nickel-Steel," by Prof. Wm. Campbell and Mr. H. B. Allen, was presented by title.

GRAIN SIZE IN STEEL.—Prof. H. M. Howe gave "The Life History of Cells and Grains in Steel," but for lack of time to present it the paper was taken as read. Its nature hardly permits summarizing its contents briefly.

QUALITY OF STEEL IN STRUCTURAL SHAPES.—This subject was discussed by Prof. E. L. Hancock (Worcester Polytechnic Institute, Worcester, Mass.) at the 1910 meeting of the society, with the purpose of showing from experimental result that the metal at the junction of flange and web of I-beams and channels is inferior to the metal in the body of flange or web. At the present meeting he reported extensive further experiments carried out during the past year, and the trend of the new results is to overthrow the idea that there is great lack of strength at the root of the flange. We hope to be able to give an abstract of the results later. One of the phenomena which appeared to occur in the tests was that test-pieces whose limit of proportionality had been lowered by overstrain would, if allowed to rest a long time, regain their original quality. Referring to this, Mr. R. W. Hunt (Chicago, Ill.) said that in wire-drawing if the wire is allowed to rest a very long time it recovers so that it can be drawn farther without previous annealing.

Sand, Cement and Concrete.

Two papers which recorded experiments on the swelling and shrinkage of concrete and cement mortar under the action of water and drying aroused much interest. The paper of Prof. A. H. White (Univ. of Michigan, Ann Arbor), entitled "Destruction of Cement Mortars and Concrete through Expansion and Contraction," was printed in our issue of July 6, 1911, pp. 26-30. It showed that extensive volume changes occur in mortars and concrete by change from water-soaked to dry condition or the reverse; and more important still, that on returning to the original condition the volume does not reach the original value, the reverse change being greater than first change. Neat cement mortar shows by far the largest changes, but they are not of negligible amount even in lean mortars and in concrete. Cases of disintegration of concrete sidewalks were studied, with the conclusion that the destruction was due to such volume changes as observed in the experiments.

Prof. A. T. Goldbeck (Lafayette College, Easton, Pa.) reported similar experiments, under the title "The Expansion and Contraction of Concrete while Hardening." His test-pieces were much larger than those of Prof. White, being 8 × 8 × 60 ins., but the range of the work was less, and the duration less than a year as against the three and four years covered by Prof. White. The results of the two investigators agreed very well, however.

Discussing the subject, Prof. H. C. Berry (Univ. of Pennsylvania, Philadelphia) reported that in several cases he had found anomalous action of concrete, i. e., expansion when setting in dry air, and shrinkage when setting in water; this was with 1:2:4 and 1:2½:5 Portland mixtures. The expansion of the air-stored samples was about 0.0001 in 30 days, and the contraction of the water-stored pieces was of about the same amount. These phenomena were explained by Prof. White as being due to early erratic actions often noticed in his own experiments during the first month. Mr. R. L. Humphrey (Philadelphia, Pa.) criticized the small size of test-piece used by Prof. White, and held that larger specimens would give different results. Small pieces soak through readily and so give exaggerated figures, as compared with larger pieces. As to the destruction of concrete sidewalks mentioned by Prof. White, he remarked that sidewalks are exposed not only to wetting and drying but also to severe thermal stresses, which latter are probably of predominant influence. Mr. S. E. Thompson (Newton Highlands, Mass.) said that he had measured the lengths of several long walls at different temperatures, and had deduced that the entire expansion could be accounted for as temperature expansion. Mr. A. S. Cushman remarked on the bearing of the reported observations upon the colloidal theory of cement-set, and said that by this theory the volume changes should be greatly reduced after heating; Prof. White said that in a few experiments made on previously heated bars he had found the swelling and shrinkage much reduced. There was also some discussion of the Charlestown concrete seawall disintegration, which Prof. White wanted to attribute to volume changes under alternate wetting and drying. Mr. Thompson, however, remarked that the wall is always soaked through, and Mr. Humphrey charged the disintegration to poor workmanship.

EFFECT OF STEAM ON CONCRETE.—Mr. Rudolph J. Wig. (U. S. Geological Survey, Washington, D. C.) gave the results of tests made in 1907 and 1908 in the Structural Materials Testing Laboratory of the Geological Survey at St. Louis, Mo., in a paper entitled "The Effect of High-Pressure Steam on the Crushing Strength of Concrete." It was found that the crushing strength of the concrete blocks increased with the increase of pressure of the steam used for curing the blocks (pressures up to 80 lbs. per sq. in. tried), and increased with the time of exposure to the steam (3 hrs. to 48 hrs. exposure tried). Thus, untreated 1:4 mortar at 2 days age had a strength of 610 lbs. per sq. in., while if exposed to 80-lb. steam during the second 24 hrs. the strength was 4,500 lbs. per sq. in. All the pieces increased in strength with age; the normal piece increased to 2,350 lbs. per sq. in., and the piece treated with 80-lb. steam (24 hrs.) increased to 5,350. The effect of increasing the time of exposure to the steam was to increase the strength, to a maximum for the longest period tried (48 hrs.); but with the longer treatments there was little or no further gain in subsequent aging. The tests with "damp" mixture (the above results being for "quaking" mixture) were anomalous in giving highest strength in the piece exposed to steam for only 12 hrs. A curious fact is that, in both consistencies, the pieces exposed for only a short time, 3 hrs., were weaker than the untreated samples, at 28 days age; and in the case of the "damp" mixture the untreated block at 28 days (2,030 lbs.) was stronger than all except the 12-hr. sample (2,480 lbs.) at the same age.

Incrustations which formed in concrete drain pipes lying in stagnant water led Mr. A. O. Anderson (Lake City, Iowa) to undertake experiments to learn the causes of such incrustations. Placing pieces of concrete pipe in jars of rainwater, some sealed and some open to the air, he found that in periods of 270 to 670 days but little incrustation or adherent sediment formed on the pieces in the sealed jars, whereas those in the open jars usually formed such sediments. He concluded that the action of carbon dioxide taken from the air, in combination with dissolved lime salts, caused the incrustations. Recently-made pipe is most liable to the appearance of incrustation, and rough surfaces favor its formation, as compared with well-troweled smooth surfaces.

Two other papers on cement and concrete were read by title: "The Properties of Magnesium Cement, Mortars and Concretes," by Profs. Charles Derleth, Jr., and A. C. Alvarez (Univ. of California, Berkeley); and "The Determination of Stresses in a Reinforced-Concrete Member Subject to Axial Load in Flexure," by Mr. S. Ingberg (University of Illinois, Urbana). The latter paper gives the results of tests of 2 test-beams of 8 × 11-in. cross-section, under flexure while end compression was applied. Comparing with theoretical calculation, the author finds satisfactory agreement, both with straight-line and with parabolic stress-variation assumed in the beam.

TESTS OF SAND AND GRAVEL.—Another different subject was dealt with by Mr. H. S. Greenman (Engr. of Tests, Dept. of State Engineer, Albany, N. Y.) in a paper "Practical Tests of Sand and Gravel Proposed for Use in Concrete." Quoting results from tests made in the New York State laboratory, the author showed by comparison the influence of percentage of voids, presence or absence of fine grains, and percentage of loam, upon the strength of mortars made from the sand. Generally, strength increased as the percentage of voids decreased, and increased with amount of loam up to a certain degree. He urged that tests for voids, granulometric composition and percentage of loam be made in every cement laboratory on every sand proposed for use. He also recommended that field tests be devised and used regularly by contractors, and suggested for the purpose a loam test by dropping sand into water, and a test for voids by means of a percolator. He also advocated molding frequent mortar cubes or cylinders in the field, to keep a check on actual results obtained.

Some discussion followed, but it mainly emphasized the uncertainties surrounding the selection and judging of sands. Mr. S. E. Thompson (Newton Highlands, Mass.) spoke of the bad behavior of sand containing lignite particles, which caused checking and cracking of the concrete made from it. Mr. R. L. Humphrey (Philadelphia, Pa.) and others told of cases of mysterious action of sand, the sand giving poor results with one brand of cement and good results with another. Mr. C. M. Chapman (Westinghouse, Church, Kerr & Co., New York City) in particular mentioned a case of this sort, where a tested and approved cement did not set up with a certain sand, while the same sand with another brand of cement worked satisfactorily; in this case neither weather or temperature conditions nor granulometric composition seemed to give any explanation. Mr. Humphrey characterized the sand test subject as the most important in the concrete field, and especially in small work where preliminary mortar tests cannot be made. Mr. W. M. Kinney (Pittsburg, Pa.) claimed that sand which proves good in the laboratory may not turn out to be good in the field.

Miscellaneous Subjects.

Mr. John C. Trautwine, Jr. (Philadelphia, Pa.), gave the results of two crushing tests of cast zinc blocks. The stress-strain curves obtained are curved, without definite elastic limit. The ultimate strengths were well above 40,000 lbs. per sq. in., but the pieces did not break. The modulus of elasticity for the lower loads was about twice as great as that found by Prof. Thurston and by J. C. Trautwine (senior), being about 350,000 lbs. per sq. in. between loads of zero and 20,000 lbs. per sq. in.

Prof. F. P. McKibben (Lehigh University, Bethlehem, Pa.) described the new Fritz Engineering Laboratory of Lehigh University.

Several papers presented by title have not been included above: "Asphalt Cement for Use in Sheet-Asphalt Pavements; Physical and Chemical Tests to Determine Quality," by Mr. J. W. Howard, of New York City; "Some Causes of Failures in Metals," by Prof. Henry Fay, of the Massachusetts Institute of Technology, Boston; "Notes on Anti-Friction Alloys," by Prof. William Campbell, of Columbia University, New York

City; "Organic Residues from Soluble Bitumen Determinations," by Messrs. Prevost Hubbard and C. S. Reeve, of the Office of Public Roads, Washington, D. C.; and "Recent Analyses of Tests of Structural Timbers made by the Forest Service," by Mr. McGarvey Cline, Director of the Forest Products Laboratory, Madison, Wis.

A Luncheon to Mr. George H. Frost.

A luncheon, in celebration of the seventy-third birthday of Mr. George H. Frost, founder of Engineering News and president of the Engineering News Publishing Co., was given at the Machinery Club, in New York City, on Friday, July 7. The guests at the luncheon were chiefly engineers who were personal friends of Mr. Frost in the early days of Engineering News.

While the vacation season causes many to be away from their offices at this time, a party of 33 were brought together at the luncheon, as follows: Hon. Ernest R. Ackerman, Alfred P. Boller, C. W. Buchholz, Clemens Herschel, F. R. Hutton, Emil Kuichling, Robert W. Lesley, Nelson P. Lewis, Gustav Lindenthal, Col. E. D. Meier, Mansfield Merriman, Spencer Miller, Alfred Noble, John F. O'Rourke, Joseph O. Osgood, James Owen, William Barclay Parsons, George H. Pegram, William L. Saunders, Charles E. Speirs, T. Kennard Thomson, John C. Trautwine, Jr., Samuel Whinery, Hon. William H. Wiley, William J. Wilgus, George H. Frost, Charles Whiting Baker, Alfred E. Kornfeld, F. C. Wight, F. E. Schmitt, Charles Frost and Francis W. Frost.

THE LUNCHEON TO MR. GEORGE H. FROST.

Reading from left to right: Messrs. Meier, Saunders, O'Rourke, Kuichling, Schmitt, Lindenthal, Wilgus, Miller, Pegram, Buchholz, Merriman, Lewis, Parsons, Boller, Baker, George H. Frost, Kornfeld, Ackerman, Wiley, Noble, Herschel, Whinery, Osgood, Owen, Wight, Lesley, Thomson, Speirs, Charles Frost, Francis Frost, Trautwine and Hutton

Letters of regret were received from many others. Following the luncheon, informal speeches were made by Mr. William Barclay Parsons, Major William H. Wiley, Mr. Robert W. Lesley, of Philadelphia, Mr. William L. Saunders, Mr. John F. O'Rourke, Hon. Ernest R. Ackerman, President of the New Jersey Senate, and Mr. Frost.

The Bridgeport Wreck on the New York, New Haven & Hartford R. R.

One of the most serious accidents in the history of the New York, New Haven & Hartford R. R. occurred at 3.30 a. m. on the morning of July 11, at a point about 1½ miles west of Bridgeport, Conn. The wrecked train is known as the Federal Express, and runs from Washington, D. C., over the Pennsylvania R. R. to Jersey City, where it is ferried around Manhattan Island to the Harlem terminal of the New York, New Haven & Hartford R. R., over which line it runs to Boston.

On this particular morning the train was considerably over an hour late in leaving the Harlem yards. The regular engine crew of the train had been given a lay-off and the substitute engineer and fireman were, according to reports, not as familiar with the road. This train usually makes no stop between the Harlem yards and New Haven, Conn. It stops at Bridgeport only on notice to the conductor to leave passengers. On this morning, however, orders had been given to the engineer, before leaving Harlem, to make this stop.

About two miles west of Bridgeport there is a long easy curve (not over 2°) with a central angle of perhaps 20° to 30°. Almost at the P. T. of this curve there is a four-track cross-over operated from a switch tower at the crossing of the track and Fairfield Ave. Eastbound express trains which are to stop at Bridgeport have to cross at this point from the inside express track to the outside local track. There is some evidence that this crossover was installed but about three weeks ago.

The train rules of the New York, New Haven & Hartford R. R. require the engineman to take all cross-overs at a speed of not more than 15 miles per hour. Whether from forgetfulness that he had to make the Bridgeport stop or as to the exact location of this cross-over, or inability to see the switch lamp on account of the curve, or in the hurry to make up time, the engineman ran over this cross-over at full speed, the train making, it is said, 60 to 70 miles per hour.

As mentioned above, this cross-over is but a few feet west of the bridge by which the railway is carried over Fairfield Ave. This bridge is a through plate-girder, having a girder between each two tracks, with the ordinary open floor construction. About 200 ft. east of this crossing there is a factory siding, leading from the main line track to street level on a 1.5% grade. West of the crossing the tracks are on an embankment, about 20 ft. high. East of the crossing the tracks are on a fill between vertical masonry walls, 12 ft. high and 66 ft., outside to outside. The tracks are 12 ft. between centers.

The derailed engine crossed the bridge and struck this down grade siding and then plunged over the wall to the street below. The derailed train was composed of the United States Fish Commission car, a baggage car, a day coach and six Pullman sleeping cars, a total of nine cars. The first six cars were thrown over the embankment or off the bridge, the third Pullman landing directly on top of the preceding one was not entirely derailed or seriously smashed. The last two did not leave the tracks. The derailed cars were in some cases entirely overturned and badly smashed.

The outside girder of the Fairfield Ave. crossing was torn off as cleanly as if cut by an oxy-acetylene flame. Every evidence existed that the momentum of the train had been tremendous.

The list of dead to date is placed at 12, including the engineman and fireman. About 45 were more or less seriously injured, some fatally.

The official statement of the railway company places the blame upon the dead engineman for exceeding the speed limit over the cross-over.

A CONFUSION OF TRAIN ORDERS is assigned as the cause of a collision on the Minneapolis, St. Paul & Sault Ste. Marie Ry. July 5, near Superior, Wis., between an extra and a gravel train. Four men were killed and three others injured.

THE STEAMER "SANTA ROSA," owned by the Pacific Coast Steamship Co., went ashore before dawn July 7 two miles north of the lighthouse on Point Arguello, Cal. Sixteen of her passengers were drowned, according to press reports, some of them by the capsizing of a small boat in which they were being transferred to another vessel.

FIRE AT THE RAILWAY SHOPS of the International & Great Northern R. R. at Palestine, Tex., July 3, destroyed the woodworking and upholstering departments with a loss estimated at $90,000.

A POWDER MILL EXPLOSION July 5 at the Standard Powder Works, Horrell Station, Pa., resulted in the death of four men. Reports state that the plant was entirely destroyed with the exception of the storage house. The loss is placed at $20,000.

The plant of the Marietta Torpedo Co., near Marietta, Ohio, was completely wrecked July 3 by an explosion which involved some six hundred quarts of nitroglycerine. Considerable damage was done to windows in the town of Marietta, about three miles away. Both this explosion and the one at Horrell Station, Pa., are ascribed to the excessively hot weather.

A TRAVELER COLLAPSED July 10 at the plate-girder viaduct under construction for the Western Maryland R. R. at Salisbury Junction, Pa. Five men were killed and two others seriously injured. The accident occurred when the traveler was carrying a 14-ton girder.

AN EXPRESS TRAIN WRECKED A LOCAL on the Camden & Atlantic division of the Pennsylvania R. R. July 3 under rather peculiar circumstances. The local, northbound, stopped at Lucastown, N. J., to take a siding in order to allow a northbound express train to pass. The brakeman in some way mistook the switch stand and threw the switch for the cross-over to the southbound track instead of the siding switch. He apparently did not notice the mistake and the local was backed out until the two rear cars were on the southbound track. These two cars were promptly struck and demolished by a southbound express train. Two passengers in the wrecked cars were killed and 17 others injured. The express was too close when the cross-over switch was thrown, according to reports, to be stopped by the signals automatically set against it by the throwing of the switch.

PANAMA CANAL EXCAVATION during June totaled 2,646,442 cu. yds., a daily average of 101,986 cu. yds. for each of the 26 working days. The amount of concrete laid during June was 104,914 cu. yds., and 742,177 cu. yds. of fill were placed in dams. The rainfall for the month was 7.14 ins.

ICE ACCUMULATION ON WIRES.—Maj. Charles Keller, Corps of Engineers, U. S. A., in the July-Sept., 1911, issue of "Professional Memoirs, Corps of Engineers, U. S. Army and Engineer Department at Large," presents a cross-section of an ice-incrusted telephone wire after a sleet storm. The wire is a No. 9 steel telephone wire and the surrounding ice is an oval section ¾-in. wide by 1 in. deep, with a total area of 0.5575-sq. in. The area of the wire itself is 0.0103-sq. in., making the total area of the cross-section of the ice 0.5472-sq. in. This gives a volume of ice per lin. ft. of wire of 0.00381-cu. ft. or about 0.2185-lb.

IN BUILDING A RESERVOIR for the new water supply of Birkenhead, England, about 1,500,000 cu. yds. of peat and soil are to be removed to avoid risk of contamination of the stored water. It is hoped to use part of the peat for fuel to develop power in connection with the construction work. The conduit from the reservoir to Birkenhead will be 20 to 30 ins. in diameter and will furnish about 7,000,000 gallons of water per day. The reservoir will be about 1,190 ft. above sea level. The total cost of the work is estimated at about $6,500,000.

AN EXTRAORDINARILY INTENSE FIRE destroyed two reinforced-concrete pier sheds in the port of Marseilles, France, about a year ago and is described in some detail in the current issue of the "Annales des Ponts et Chaussees." These sheds were founded on solid earth quay walls and were of reinforced-concrete skeleton construction, paved with both sandstone and pressed asphalt blocks and separated into bays by hollow-brick walls, reinforced with wire mesh. On July 26, 1910, a pile of sacks containing cocoanut shells, amounting to some 3,000 tons in all, caught fire and soon the blaze was far beyond the control of the very extensive fire-fighting facilities of the port. The material is very combustible and the fire burned with great fierceness for two days and it was nearly a month before entrance could be gained to the sheds. By that time the entire structure was destroyed. The columns, beams and slabs of reinforced concrete failed by the splitting of the concrete over the steel, which destroyed the necessary bond and consequently the integrity of the structure. The hollow-brick walls failed before the concrete members began to fail. Strangely enough the asphalt paving was not seriously damaged, although the sandstone blocks were so cracked as to render their replacement necessary.

THE ELECTRIFICATION OF THE RAILWAY TERminals of St. Louis has been investigated by a Committee of the Civic League of St. Louis, of which Prof. A. L. Langsdorf, of Washington University, was Chairman, and Mr. R. H. Phillips and Prof. J. L. Van Ornum members. The Committee finds that to completely electrify the terminal railway lines of St. Louis would involve an outlay of over $17,000,000. An average cost per mile of $65,300 is taken, including rolling stock and signaling. The Committee's conclusions are as follows:

1. Electrification of the St. Louis terminal is very desirable, as it would increase the comfort and convenience of the traveling public and would eliminate the smoke now contributed by the railroads which amounts to about one-third of the entire amount of the city's smoke. But, as stated above, it does not follow that electrification is the only solution of the smoke problem.
2. Electrification of railroad terminals for passenger and freight traffic is quite applicable from an operating standpoint.
3. The elimination of the principal grade crossings is necessary on grounds of public safety, and should be completed before electrification is begun.
4. The fixed charges on the capital that would be required to pay for local electrification should be absorbed only in part in through passenger or freight rates. Since the probable increase in suburban traffic alone will not justify electrification in St. Louis, the money to pay for it might either be diverted from needed additions to terminal facilities, or might necessitate increased local freight or switching charges; resulting in either case in an added burden upon the manufacturing and commercial industries of the city, which should be taken into consideration.

TESTING OF BALLOON FABRICS has been carried on extensively at the Prussian Königliche Materialprüfungsamt, at Gross-Lichterfelde, Berlin. This work is a development of the testing of crude and manufactured rubber, which has long been in the hands of a special department of the institution. The rubber testing work and some of its recent results are set forth in a book published a few months ago by two members of the laboratory staff "Der Kautschuk und seine Prüfung," by Hinrichsen & Memmler (Eng. Lit. Supp., Dec. 15, 1910). The testing of balloon fabrics was described by the director of the institution, Prof. A. Martens, in an address before the Prussian Academy of Sciences a few months ago. The principal tests other than analytical are for strength, permeability with respect to gas, heat conductivity, and absorption of moisture. Tensile tests are made in different directions in the sheet, on strips 2 × 14 ins.; the results are expressed by "rupture length" as in case of paper tests. It is important to maintain the humidity constant, as varying moisture affects the strength; 65% is taken as standard. However, to meet the objection that simple tensile tests may not fully represent the action of the material when used in a balloon, tests have been devised to imitate this action. Martens' own form employs a circular piece of fabric held down by a rim and subjected to the pressure of compressed air from below, the bursting pressure and the maximum height of bulging being noted. Rupture usually occurs at the center. This bursting test is only comparative, as it depends on diameter of piece, character of retaining-ring surface, etc., which conditions have not yet been standardized. Permeability to air may be tested by measuring the air leakage of a circular sample under fixed pressure. Hydrogen permeability is measured by allowing hydrogen to diffuse from a mixture of air and hydrogen on one side of the sample to air on the other side, the latter being drawn out continuously and its hydrogen burned and weighed as water. Heat absorption is measured by covering the open top of a black vessel with the sample, subjecting it to definite radiation, and measuring the temperature rise in the vessel; this is a comparative test only. Prof. Martens points out the need of testing balloon fabrics not only in new condition but also after a period of outdoor exposure.

Personals.

Mr. C. E. Bacon, Chief Engineer of the Fort Worth, Tex., water-works department, has resigned.

Mr. W. D. Marks, M. Am. Inst. E. E., of New York City, has been engaged by the city of Providence, R. I., to make a study of the lighting situation in that city.

Dr. Arthur Stanley Mackenzie, Professor of Physics at Stevens Institute of Technology, Hoboken, N. J., has been elected President of Dalhousie University at Halifax, N. S.

Prof. Louis D. Huntoon, M. Am. Inst. M. E., formerly of the Department of Mining and Metallurgy at Sheffield Scientific School, Yale University, has opened an office at 42 Broadway, New York City, as a consulting engineer.

Mr. H. F. Gamm, M. Am. Inst. M. E., has resigned as Chief Engineer of the Oxford Copper Co., of Bayonne, N. J., and after a few months' rest will devote his time to practice as a consulting engineer on industrial plants.

Mr. Henry B. Drowne, Assoc. M. Am. Soc. C. E., has resigned as Instructor in Civil Engineering at Brown University, Providence, R. I., to become Instructor in Highway Engineering at Columbia University, New York City.

Mr. N. B. Ayers, M. Am. Soc. M. E., of Dayton, Ohio, has resigned as Chief Engineer of the Dayton Power & Light Co., and has organized the Ayers Engineering Co., to carry on the practice of general power plant engineering.

Mrs. Logan Waller Page, wife of the Director of Public Roads of the Department of Agriculture, was one of the passengers on the Federal Express, wrecked at Bridgeport, Conn., on July 11, but fortunately escaped with minor injuries.

Mr. Clifford M. Hathaway, Jun. Am. Soc. C. E., has resigned his position with the State Board of Public Roads of Rhode Island to accept a position as Assistant Engineer with Mr. A. H. Blanchard, M. Am. Soc. C. E., consulting highway engineer, of Providence, R. I.

Mr. Fritz A. Lindberg has become a member of the firm of Brill & Gardner, engineers, 1133 Marquette Bldg., Chicago, Ill. Mr. Lindberg is a graduate of the Armour Institute of Technology, Class of 1901, and has been continuously associated with this same firm since his graduation.

Lord Strathcona, Hon. M. Can. Soc. C. E., has announced his intention of retiring from the position of High Commissioner of Canada. Lord Strathcona is 91 years old and has been intimately connected with the railway and industrial development of the Dominion for many years.

Mr. C. L. Slocum, Assoc. M. Am. Soc. C. E., formerly Assistant Engineer of the New York Extension of the Pennsylvania R. R., is now on the engineering staff of the St. Lawrence Bridge Co., the contractors for the new Quebec Bridge. His headquarters will be in the Beardmore Bldg., Montreal, Que.

Mr. Ralph W. Pope, Secretary of the American Institute of Electrical Engineers since 1883, has resigned and been made Honorary Secretary. Mr. Pope is 67 years old and was for many years prominent in technical journalism. He was formerly Associate Editor of the "Electrical Engineer" and the founder and Editor of "Electrical Power."

Gen. Theodore A. Bingham has resigned his office of Chief Engineer of the Bureau of Highways, Borough of Manhattan, New York City, to which he was appointed on May 1 of this year. Gen. Bingham is reported to have been unsuccessful in having the Bureau reorganized on an efficient basis, and in his letter of resignation states that he is "not willing merely to hold this office and accomplish no important work." Soon afterwards Gen. Bingham was appointed Consulting Engineer of the Department of Bridges at a salary of $7,500 per annum.

Mr. Louis H. Evans, M. Am. Soc. C. E., and Mr. Hugh Pattison, Assoc. Am. Inst. E. E., have been engaged by the Association of Commerce of Chicago, Ill., to make an investigation into the subject of the electrification of the railway terminals in Chicago. Mr. Evans is a consulting engineer of Chicago and was formerly Chief Engineer of the Chicago Junction Ry. Mr. Pattison was until recently Superintendent of Construction for the Pennsylvania Tunnel & Terminal R. R. Co., at New York City.

Mr. Dow S. Smith, formerly General Superintendent of the Brooklyn Rapid Transit Co., Brooklyn, N. Y., has been made General Manager of the Dan Patch Electric Lines. The Dan Patch Electric Lines are suburban lines running out of St. Paul and Minneapolis, Minn. The president of the company is Mr. M. W. Savage, owner of a certain fast horse; hence the name of the electric line. After leaving the Brooklyn Rapid Transit Co., Mr. Smith was for a number of years connected with the Twin Cities Rapid Transit Co., of St. Paul and Minneapolis.

Mr. John M. Whitman, Vice-President of the Chicago & Northwestern Ry. in charge of construction, has retired after 55 years of active engineering work. He was born in Onondaga County, New York, in 1837. He began his railway career in 1856 as a rodman in the engineering department of the Illinois Central R. R. After two years of this work he became a leveler on the work of enlarging the Erie Canal. From 1860 to 1865 he was the engineer in charge of construction on the Brunswick & Albany R. R. During the four years following he was in charge of the construction of the Chicago Stock Yards and on the work of deepening the Illinois and Michigan Canal. In 1869 he returned to railway work as Engineer in Charge of Construction of the Iowa Midland Ry. From 1872 to 1880 he was Engineer, Superintendent and Receiver of the Chicago & Pacific Ry. From that time he has been continuously in the service of the Chicago & Northwestern Ry. as Division Superintendent, General Superintendent, General Manager and Vice-President.

Obituary.

Mrs. Charles D. Walcott, wife of the Secretary of the Smithsonian Institution, was killed in the wreck of the Federal Express on the New York, New Haven & Hartford R. R. on the morning of July 11, at Bridgeport, Conn. The marriage of Mr. and Mrs. Walcott took place in 1888 at Rochester, N. Y. Dr. Walcott was [Direc]tor of the United States Geological Survey from [1]894 to 1907, and is one of the most prominent among [A]merican scientists. The sympathy of the many engine[ers] who have been associated with Dr. Walcott will go out to him in his bereavement.

Nicholas Densmore died of smallpox in the small village of Yumala, Bolivia, on June 10. The village is located near the Chacarilla copper mines, and Mr. Densmore was visiting the locality in connection with some important mining claims. He was lodged in the village in a bed in which a child had died of smallpox only a few days previously. Mr. Densmore was a native of Minnesota, and about sixty years of age. He spent the greater part of his life in railroad construction in West Virginia, Kentucky and Tennessee, but had been in South America for the past fifteen years. He was associated for a number of years with the firm of Bolan & Dillon on railway construction, working on the Guayaquil & Quito R. R., the Cerro de Pasco and the Bolivian Rys. For the past three years he had devoted his time entirely to his mining interests in the Quimsa Cruz Mountains and the Chacarilla copper regions. His residence was in the city of La Paz, and he was highly esteemed by his associates. His associate, Mr. Joseph Bolan (who may be addressed in care of the Aroe Tin Co. at La Paz, Bolivia), has thus far been unable to get into communication with any relatives of Mr. Densmore in the United States.

Engineering Societies.

COMING MEETINGS.

OHIO ELECTRIC LIGHT ASSOCIATION.
July 25-28. Annual convention at Cedar Point, Ohio. Secy., D. L. Gaskill, Greenville, Ohio.

SOUTH DAKOTA ENGINEERING SOCIETY.
Aug. 23-26. Annual meeting at Deadwood, S. Dak. Secy., R. G. Culberson, Mitchell, S. Dak.

TRAVELING ENGINEERS' ASSOCIATION.
Aug. 29-Sept. 1. Annual convention at Chicago, Ill. Secy., W. O. Thompson, N. Y. C. Car Shops, East Buffalo, N. Y.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
Sept. 12-15. Annual meeting at St. Paul, Minn. Secy., Clarence R. George, Houston, Tex.

MASTER CAR AND LOCOMOTIVE PAINTERS' ASSOCIATION.
Sept. 12-15. Annual convention at Atlantic City, N. J. Secy., A. P. Dane, Boston & Maine R. R., Reading, Mass.

COLORADO ELECTRIC LIGHT, POWER AND RAILWAY ASSOCIATION.
Sept. 13-15. Annual convention at Glenwood Springs, Colo. Secy., F. D. Morris, P. O. Box 1052, Colorado Springs, Colo

INTERNATIONAL ASSOCIATION OF FIRE ENGINEERS.—The annual meeting will be held at Milwaukee, Wis., Sept. 19-22. The secretary is Mr. James McFall, Roanoke, Va.

LAKES-TO-THE-GULF DEEP WATERWAY ASSOCIATION.—The annual convention will be held at the Auditorium in Chicago, Oct. 12-14. The Secretary is Mr. Thomas H. Lovelace, New Bank of Commerce Bldg., St. Louis, Mo.

ALBANY SOCIETY OF CIVIL ENGINEERS.—The annual outing and midsummer meeting was held July 8 at the site of the Ashokan Reservoir of the New York City water-supply system, about 15 miles west of Kingston in the Catskill Mountains.

AMERICAN RAILWAY ASSOCIATION.—The headquarters of this association have been removed from No. 24 Park Place to the Underwood Building at the corner of Church and Vesey Sts., New York City. The committee rooms are on the 18th floor, together with the offices of the general agent and of the bureau of explosives. The secretary's and treasurer's offices are on the 16th floor.

OHIO ELECTRIC LIGHT ASSOCIATION.—The program for the 17th annual convention at Cedar Point, Ohio, July 25-28, will include the following papers: President's Address, E. H. Bell, Youngstown, Ohio; "Why the Central Station Should Take Over the Isolated Plant," Waldo Weaver, Tippecanoe City, Ohio; "Systematic Central Station Records," O. B. Reemelin, Dayton, Ohio; "Limiting the Energy Demand of Voltage Variation of a Circuit by Floating a Fly-Wheel Motor Generator on the Line," A. M. Seeger, Toledo, Ohio; "Ornamental Street Lighting," G. A. Doeller, Dayton, Ohio; "Advantageous Uses to Which Mercury Arc Rectifiers May Be Put on Central Station Lines," J. T. Kermode, Cleveland, Ohio; "The Utility Law and Its Application to Electric Light Companies," D. L. Gaskill, Greenville, Ohio; "Pumping Water for Municipalities and for Irrigation by Electricity," B. H. Gardner, Dayton, Ohio; "Report on Insurance Rates for Electric Light Stations in Ohio," D. L. Gaskill; "Motor Driven Refrigeration," W. C. Anderson, Canton, Ohio; "The Use of Tungsten Lamps in Sign and Outline Lighting," W. B. Gauby, East Liverpool, Ohio; "Progress of Electrical Cooking in Small Towns," P. L. Miles, Cleveland, Ohio. Committee Reports on Meters, Motor Applications and Electrical Transmission.